SUPPORTS COURSES
F15EBQ
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ACADEMIC STUDENT WORKBOOK
F-15E

AIR-TO-AIR RADAR
RDR-3
AIR-TO-AIR MODES, SWITCHOLOGY & DISPLAYS

JUNE 1999

(SUITE 3 OFP)

AIR COMBAT COMMAND

ADMINISTRATIVE INFORMATION

This student workbook is designed to provide information on the F-15E, its systems and capabilities. It is not a sole source document, but is to be used in conjunction with other standard Air Force publications and technical manuals. If you find any differences between the material contained herein and other governing regulations, adhere to the regulations and notify the OPDR.

Changes to this workbook are indicated with a heavy black line in the left margin.

Forward recommendations for revision or change to 4 TS, SJAFB, NC 27531.

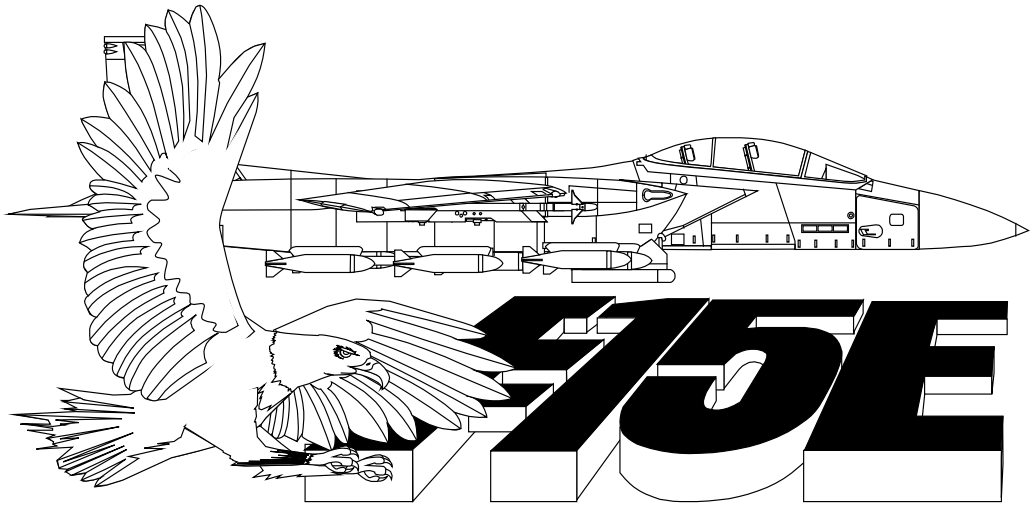
Supersedes: RDR-3, August, 1998

OPDR: 4 TS

Index of Changes

Change #	Effective Date	Pages Affected

AIR-TO-AIR RADAR



COVER

AIR-TO-AIR MODES, SWITCHOLOGY & DISPLAYS

INTRODUCTION

This RDR-3 workbook is your guide in studying F-15E air-to-air radar modes, features, switchology and displays. As part of a computer-based training (CBT) lesson, this workbook should be read prior to taking the CBT instruction.

CONTENTS:

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CRITERION REFERENCED OBJECTIVES (CROs)

1. Identify the operating characteristics and advantages/ disadvantages of these radar modes and features:

    a. Auto acquisition
    b. STT
    c. TWS
    d. DTWS
    e. NDTWS
    f. HDTWS
    g. DTT
    h. SORT
    i. FLOOD
    j. VI
    k. Track transfer logic

2. Identify the actions necessary for the following:

    a. Control of scan center
    b. Manual lock on
    c. Auto acq lock on
    d. Mode switching
    e. Designate and undesignate targets
    f. Quick step/quick pick
    g. Return to search

3. Given an A/A radar display, interpret:

   a. Target parameters
   b. Weapons employment zones on radar display

REFERENCES

TO 1F-15E-34-1-1	Systems-General
	Stick Grip and Throttle Controls
	Hand Controllers
	A/A Radar Display
	Radar Search Modes
	Acquisition Modes
	Radar Special Modes
	Radar Employment

STUDENT PREPARATION REQUIREMENTS

BEFORE THE CBT CLASS

1. Study the information contained in this workbook.

2. Read the applicable references in TO 1F-15E-34-1-1.

TEXT

The APG-70 is a coherent, multiple PRF, multi-mode attack radar. It has the capability to search for, acquire and track airborne targets as well as provide air-to-ground mapping and ranging. The radar set, in concert with TEWS indications, provides the aircrew with the options of threat avoidance, engagement and air-to-surface mission accomplishment. Several operational modes and multiple radar features assist in air-to-air weapons employment.

(To enhance readability, some information has been omitted from the radar and HUD displays throughout this workbook. Switchology presentations assume crewmember is in command of the air-to-air radar display.)

TARGET ACQUISITION

Manual Acquisition

Manual radar lock on (target designation or acquisition) is typically employed in an intercept environment at medium to long range. In search, use the TDC to bracket (enclose) the target with the acquisition symbol (Figure D-1). This is done by pressing the TDC left/right/up/down to move the acquisition symbol, likewise on the radar display.

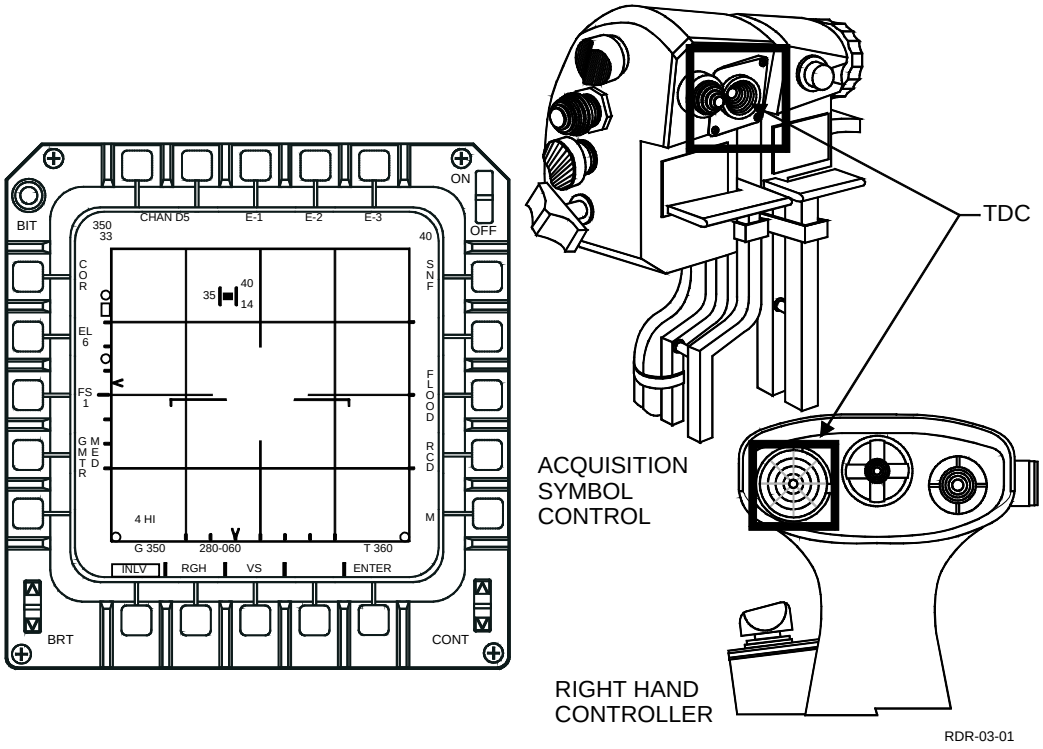

Figure D - 1. Manual Acquisition.

Depressing and releasing the FCP TDC commands the radar to enter a ±3° azimuth acquisition scan (miniraster) centered on the acquisition symbol in azimuth and search the selected bar pattern in elevation. (Two bar initially and then the selected bar pattern after 1.5 seconds.) Releasing the TDC allows manual lock on or acquisition (STT), if the acq symbol is bracketing a target. Full action and release on the RCP handcontroller trigger commands miniraster. Releasing the trigger allows lock on, if the acq symbol is bracketing a target (Figure D-2). If the pilot does not release the FCP TDC (WSO/RCP trigger) within one second, the radar enters search sort mode. Normally for a single target, depress and release the TDC/trigger in one action (< 1 sec) with the acquisition symbol on the target.

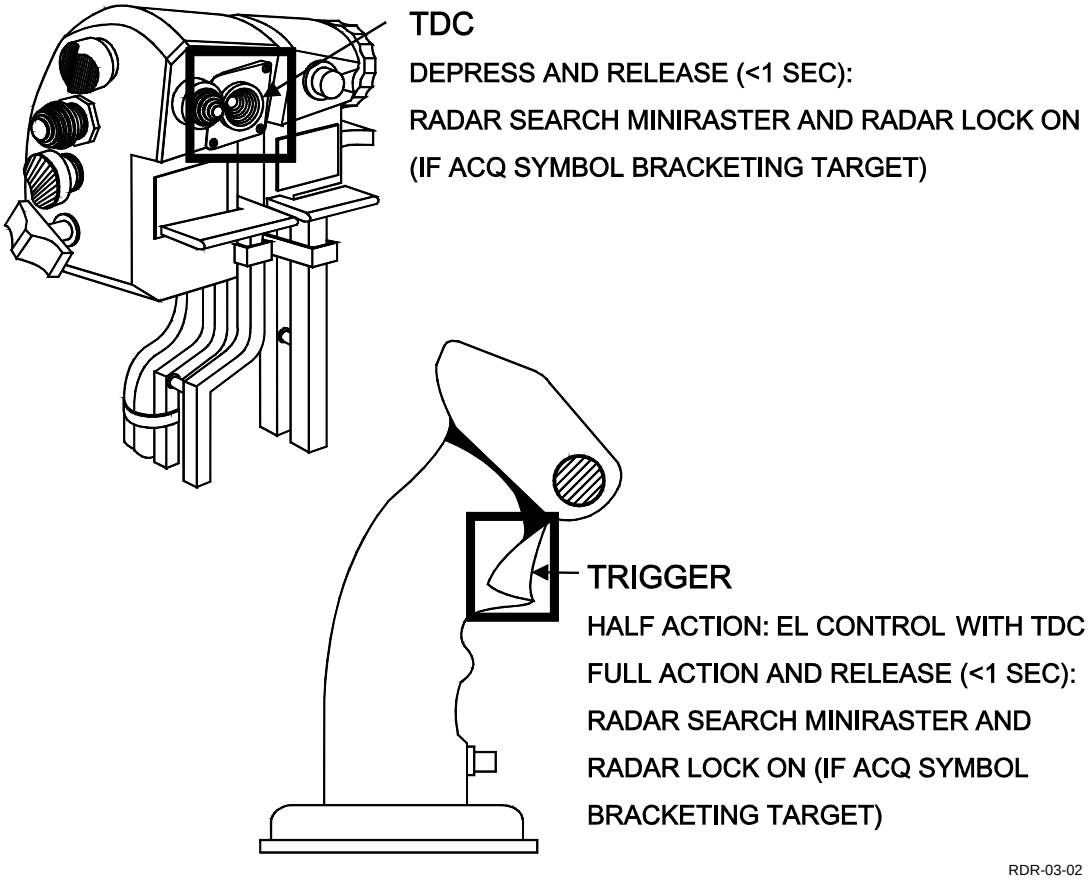
TDC
DEPRESS AND RELEASE (<1 SEC):
RADAR SEARCH MINIRASTER AND RADAR LOCK ON
(IF ACQ SYMBOL BRACKETING TARGET)
TRIGGER
HALF ACTION: EL CONTROL WITH TDC
FULL ACTION AND RELEASE (<1 SEC):
RADAR SEARCH MINIRASTER AND
RADAR LOCK ON (IF ACQ SYMBOL
BRACKETING TARGET)
RDR-03-02

Figure D - 2. Lock On.

If the radar does not achieve lock on (no target within the acq symbol or the radar is unable to acquire), the scan remains in miniraster in the bar scan selected (never less than two). Push down on the FCP/RCP auto acquisition switch (mode reject) to return to search and attempt to reacquire, if desired (Figure D-3). If the radar achieves lock on, mode reject also returns to search. Mode reject also clears the radar display of false targets ("birds").

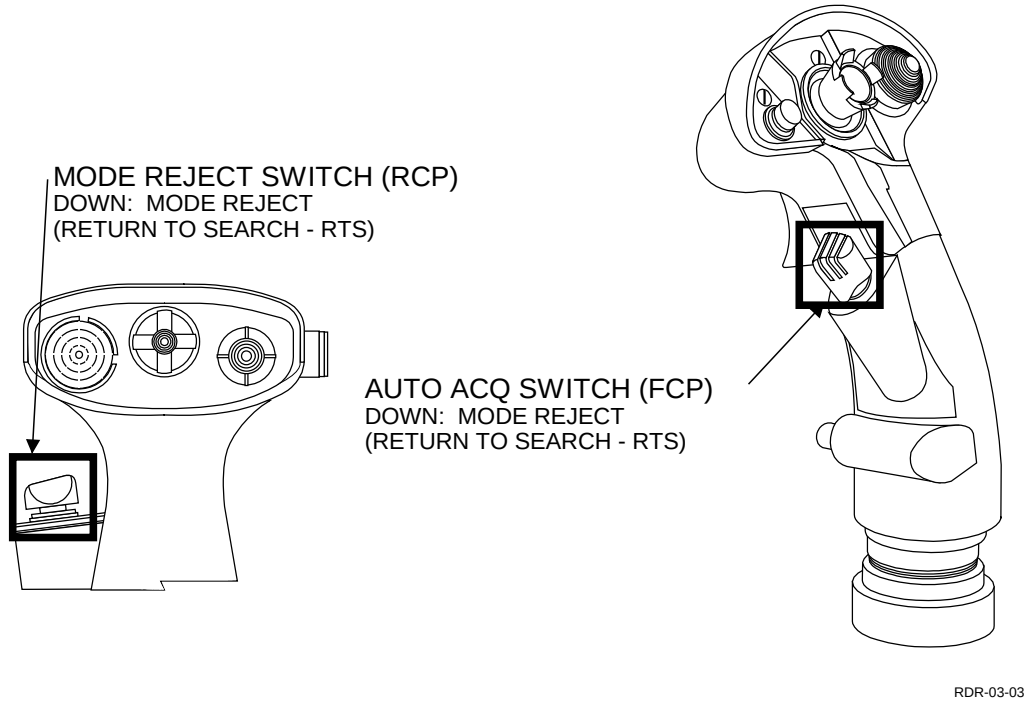

Figure D - 3. Mode Reject/Return to Search.

Auto Acquisition (Auto Acq)

There are several radar auto acq modes: supersearch (SS), boresight (BST), long range boresight (LR BST), vertical scan (VTS) and GUNS. These modes are only selectable from the front cockpit (assumes the pilot has command of the A/A radar display). These modes place the radar into a specific scan pattern, prepared for auto acquisition. When the pilot points the aircraft so that the target enters the radar scan pattern, the radar automatically acquires (locks on) the target. The pilot will normally point the aircraft by visual reference to the target. Additionally, SS, BST, LR BST and VTS are aircraft stabilized, while GUNS is INS horizon stabilized vertically and aircraft stabilized horizontally.

GUNS auto locks in MPRF out to 15 nm. SS, BST and VTS auto lock in MPRF out to 10 nm. Long range boresight auto locks in interleaved PRF out to 40 nm. The minimum range for the auto acq modes is 500 feet, except for GUNS and LR BST, which is 3000 feet due to a longer pulse width.

It is necessary to be in search or to reject any previous target lock before selecting an auto acq mode. Weapons select switch position has no effect on selecting SS, BST, LR BST and VTS with the FCP auto acq switch. Forward and release once within one second on the FCP auto acq switch selects supersearch. Forward (in less than one second) twice and release selects boresight. Forward and hold on the auto acq switch for one second or longer selects long range boresight. Aft for less than one second on the auto acq switch selects vertical scan (Figure D-4, left). The pilot activates the GUNS mode by selecting it on the throttle weapon select switch (Figure D-4, right). Auto acq modes selected on the FCP stick (auto acq switch) have priority over the GUNS mode and over any other radar search mode. When selecting auto acq modes from the FCP stick, the scan patterns continue until target acquisition or mode rejection. The GUNS auto acq scan pattern will continue until target acquisition, initiation of another auto acq mode or movement of the weapons select switch out of the GUN position. Once lock on occurs from any mode, the pilot may select any air-to-air weapon/attack steering display.

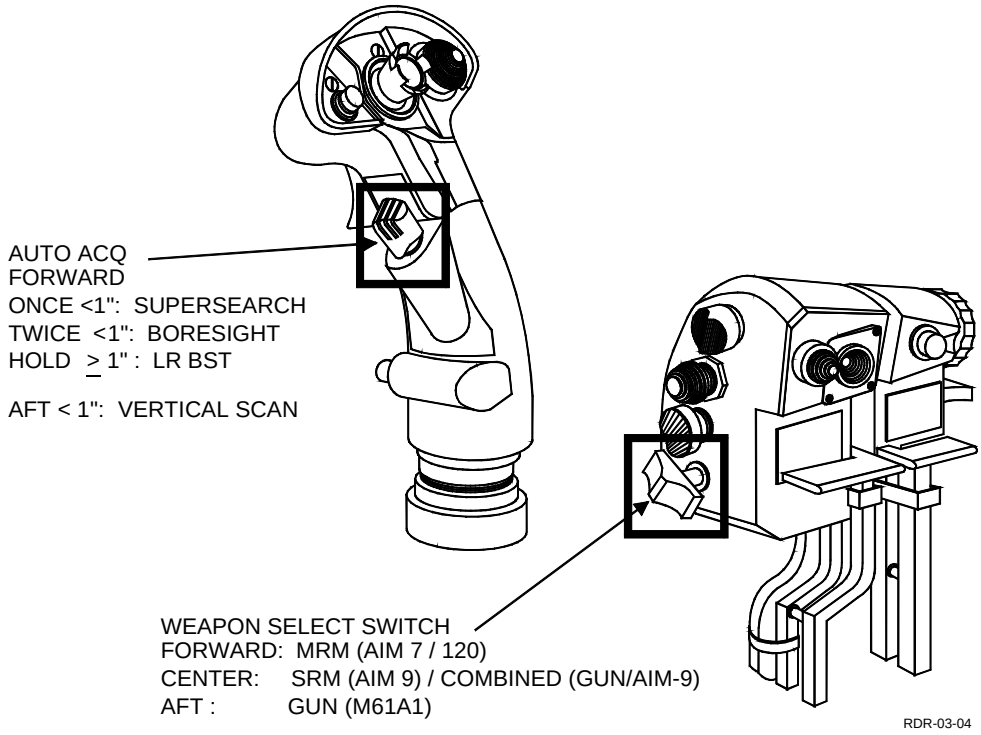

Figure D - 4. Auto Acquisition and Weapons Select.

Supersearch

When activating supersearch, the radar searches a 20° x 20° area depicted in the HUD by a 20° reference circle (Figure D-5). The scan is an aircraft stabilized, six-bar pattern centered 4° below the waterline symbol and is used to enhance lock-on capability during F-15E target maneuvering. The first target detected within this pattern is automatically acquired and tracked. It is difficult to selectively lock a particular target when multiple targets are in the FOV of supersearch.

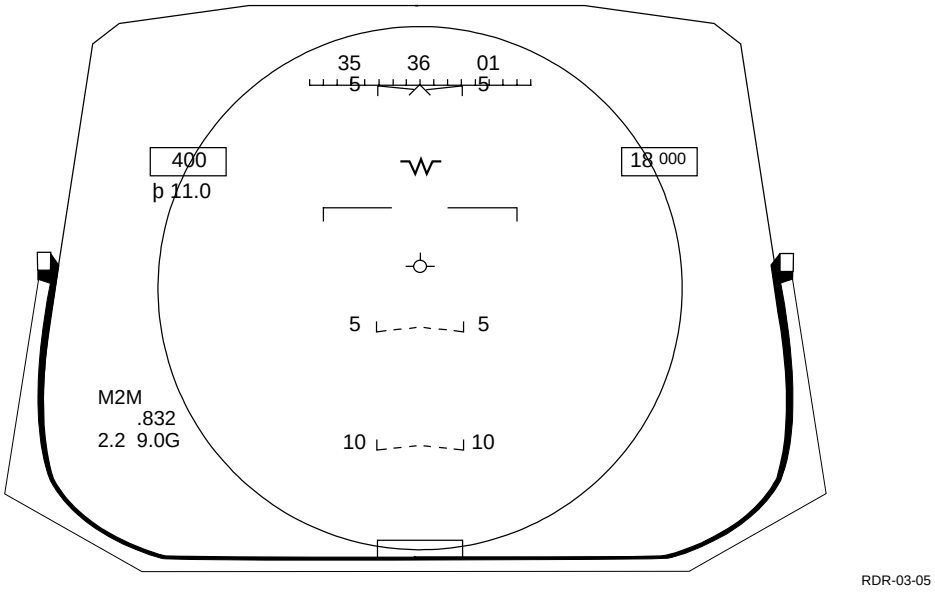

Figure D - 5. Supersearch.

The SS scan center initializes in the HUD center (-4° below waterline) and can be elevated/depressed up/down center to +28° or -19° via a full up/down action on the FCP TDC. There are no intermediate positions. This results in a corresponding scan shift that provides "vertical scan" capability with the benefit of SS area coverage (Figure D-6).

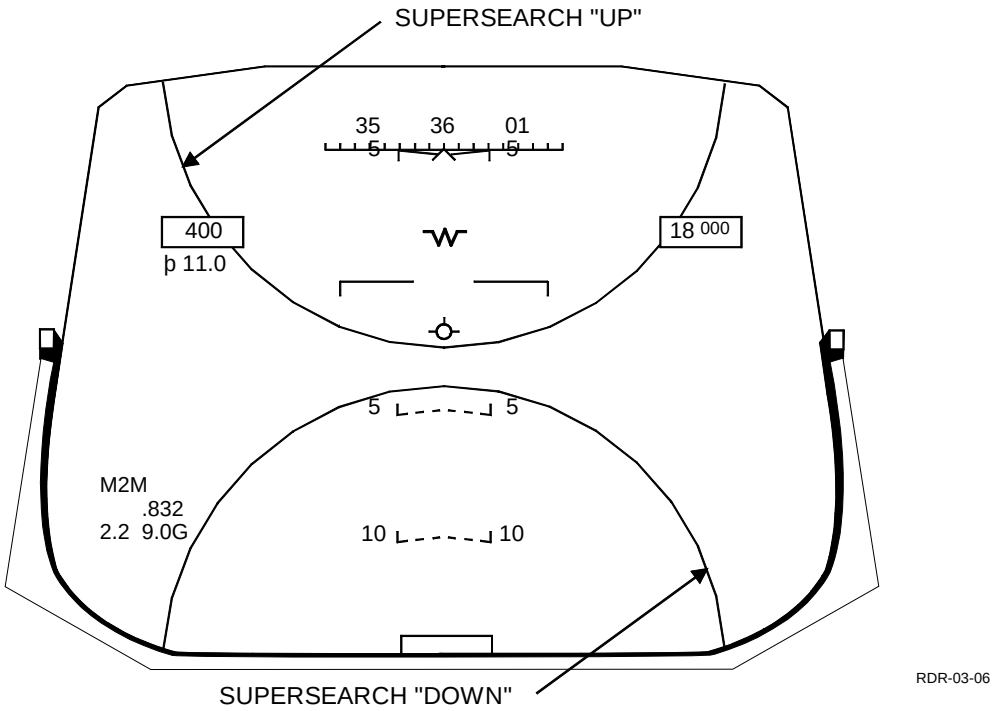

Figure D - 6. Positionable SS.

The SS half circle down picture in the HUD represents the radar scan coverage fairly accurately. However, the half circle up picture can be misleading. 28° up center from the waterline places the radar scan completely above the HUD. In fact, think of the up center scan pattern as "sitting on top of the canopy bow." This creates a SS blank area of +6° to +18° (effectively from the top of the HUD to the canopy bow) that cannot be used for acquisition.

Boresight

BST slaves the antenna to the radar boresight line (RBL) (W) and initiates an auto acquisition range search along the antenna LOS. The 4° BST reference circle on the HUD (Figure D-7) allows the pilot to maintain the target within the BST scan pattern and provides a rapid and highly discriminating lock on capability.

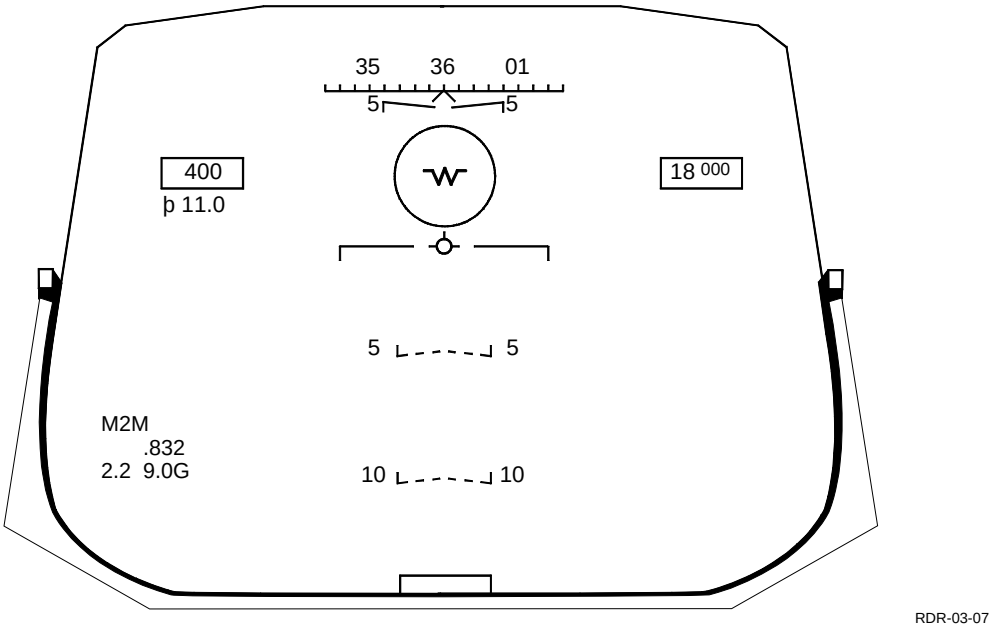

Figure D - 7. Boresight.

Long Range Boresight

Long range boresight auto acq mode acquires long range targets located along the RBL (pilot sees a contrail and wants to lock on with an auto acq mode). Once again, the radar slaves the antenna to the RBL and initiates an auto acq range search along the antenna LOS from 3000 feet out to 40 nm. The radar continues in auto acq search until it acquires a target or the crew commands return to search. A 2.5° reference circle is displayed on the HUD to approximate search pattern coverage (Figure D-8).

When entering LR BST from SS, the radar enters BST at initial actuation of the auto acq switch and then enters LR BST when the pilots holds the switch for 1 second or longer. When entering LR BST from any other mode, the radar enters SS and then goes to LR BST when the pilot holds the switch for 1 second or longer. If the radar achieves track before the pilot holds the switch for 1 second or longer, it remains in STT.

During LR BST, the radar range scale changes to 40 nm. If the crew exits LR BST to search (mode reject), the radar returns to the selected range scale.

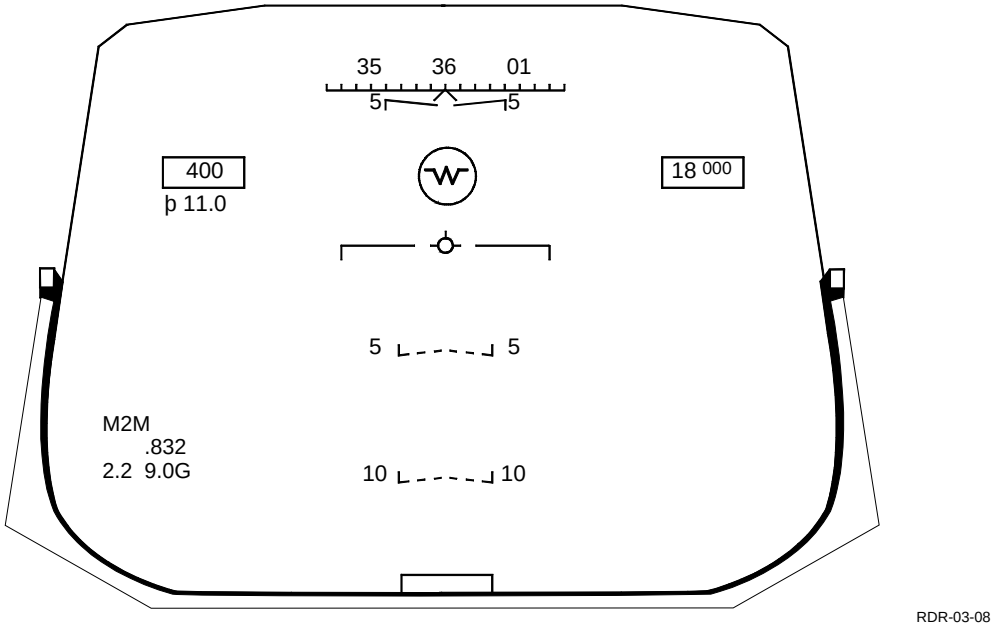

Figure D - 8. Long Range Boresight.

Vertical Scan

In VTS, the radar searches from 5° to 55° above RBL and 7.5° in azimuth. The vertical scan reference line on the HUD (Figure D-9) provides the pilot with an aiming reference to help bring the target within the radar scan pattern. This scan pattern starts at the top of the HUD (top of the line) and goes up to +55°. This mode affords fairly rapid and selective auto acquisition of visual targets positioned along the aircraft's lift vector. As an example, to auto lock a bandit spotted at about 1-2 o'clock level, thumb aft and release on the auto acq switch, and roll 90° right to place him above the HUD and on an imaginary extended VTS line of the HUD (above the center mirror is a useful reference (Figure D-10)).

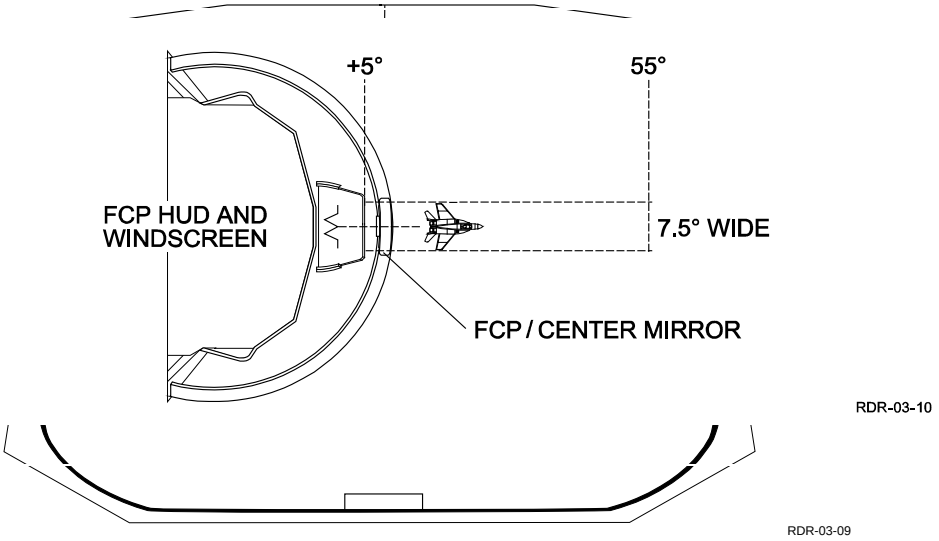

Figure D - 10. Target Positioning in Vertical Scan.

GUNS Mode

The GUNS auto acq radar scan pattern covers a large volume of airspace (60° in azimuth, 20° in elevation) and is space stabilized to the INS horizon (Figure D-11). When initialized by selecting GUN on the weapon select switch (not in STT or DTWS), the scan centers on 0° AZ (aircraft ⍭)/EL (INS horizon), but the pilot may slew via the TDC to the AZ/EL limits of the radar. Displayed altitude coverage data on the radar display is based on a fixed 7.5 nm range. The pilot changes elevation and azimuth angles by moving the acquisition symbol up/down and left/right, respectively, on the A/A radar display. Excessive look angles (i.e. acquisition symbols well above/below the center of the scope) give a false picture of actual radar coverage. After selection of GUN but prior to acquisition of a target inside 15 nm, the radar displays targets detected between 15 and 20 nm. These targets cannot be acquired with manual or auto lock while still in GUN. The pilot can select all other auto acq modes during the GUNS scan (i.e., they will take precedence over GUNS scan).

Mode reject reinitializes the scan center to 0° AZ (aircraft ⍭ / EL (INS horizon) while in GUNS search. If the radar locks and the pilot then selects mode reject, the radar initiates "bump" acquisition. During bump acquisition, the radar breaks lock, positions the scan center 5° right and 1.7° down from the original target, and resumes the GUNS scan.

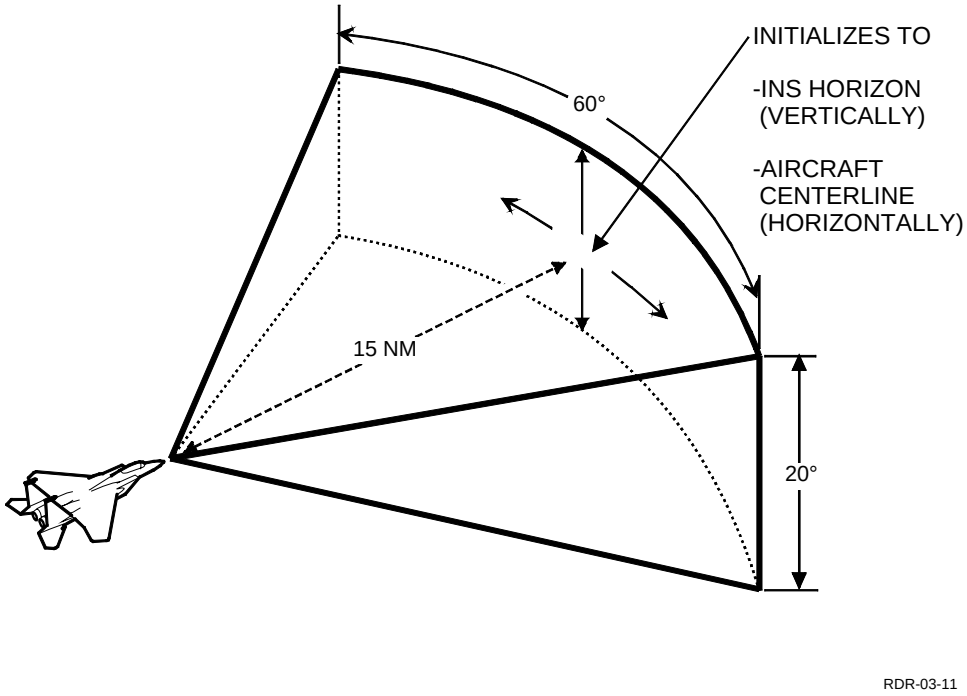

Figure D - 11. GUNS Mode.

SINGLE TARGET TRACK (STT) AND PRF TRACK TRANSFER

The primary function of single target track is to provide target data required for accurate weapon delivery. The STT mode utilizes three semi-independent tracking loops in its calculations: one for angle, one for velocity and one for range. The radar tracks the target in angle and velocity during HPRF. In MPRF, the radar tracks the target in angle, velocity and range. MPRF ranging is more accurate than the FM ranging employed in HPRF; however, AIM-7s require HPRF illumination of the target for proper guidance.

If acquisition occurs in HPRF ("HI" in radar BIT window), the radar attempts to switch to MPRF. At target ranges beyond the MPRF capability, the radar performs FM ranging every ½ second (using the HPRF waveform) to provide an approximate target range. Inside 40 nm, the radar attempts MPRF ranging every 3 seconds. When MPRF ranging is successful (target is detected in MPRF), the radar stops FM ranging, but continues to track in HPRF. Inside 30 nm, the radar transfers to MPRF track ("MED" in radar BIT window). The exact range is a function of target size and signal strength. Selecting MRM and MASTER ARM does not prevent the transfer to MPRF, unless maximum AIM-7 launch range is outside of 30 nm. This may be the case if the F-15E is at medium or high altitude, or the target is extremely high and fast.

While tracking a target in MPRF with master arm (ARM, MRM selected and an AIM-7 in priority), the radar attempts to transfer back to HPRF when target range is less than 1.2 Raero (Raero is based on MRM aerodynamic range) for frontal aspect targets and 1.05 Raero for rear aspect targets. HPRF track transfer from MPRF final track takes 1.5 to 2 seconds. However, it may never occur against a beam aspect or co-speed tail aspect target. Maneuver to move the target out of the main beam clutter, or accelerate/decelerate to shift its doppler away from the altitude line. This may allow the radar to upgrade to HPRF final track for AIM-7 launch. With an AIM-120 in priority, the radar continuously attempts to transfer to MPRF when target range is less than 30 nm.

TRACK DISPLAYS

In STT, the radar provides target range, range rate, velocity, antenna angles, and angular rates to the central computer (CC) for computation of weapon attack mode parameters. Once lock on occurs (either manual or auto acq), the track display presented is a function of the weapon select switch position. The parameters displayed include: target true airspeed, aspect angle, magnetic heading, altitude, heading vector, range and range rate (opening/closing velocity between fighter and target, or Vc).

Figures D-12 through D-19 depict a sequence of track displays from initial lock through break X (weapon select switch: MRM/SRM/GUN). Aspect angle (AA) is the angle from the tail of the target measured around to the radar line of sight from the fighter and is displayed in degrees divided by 10 (15 aspect angle equals 150°). An L or R following the aspect angle indicates which side of the target you are seeing. Altitude appears adjacent to the antenna elevation caret and above the star in thousands of feet. At the elevation caret, the dash between the first digit(s) and the last digit represents a decimal point; thus, 20-1 represents 20,100 feet. A caret on the right side of the display indicates range. Vc appears left of the range caret. The vector stick indicates target heading relative to the center scribe line (fighter heading) and will move if the target maneuvers. Bearing and range to the tracked target from the selected bullseye point appears to the right of fighter ground speed.

NOTE

The heading vector oscillates 10° to 20° (or more) in STT when there are multiple targets in the radar beam.

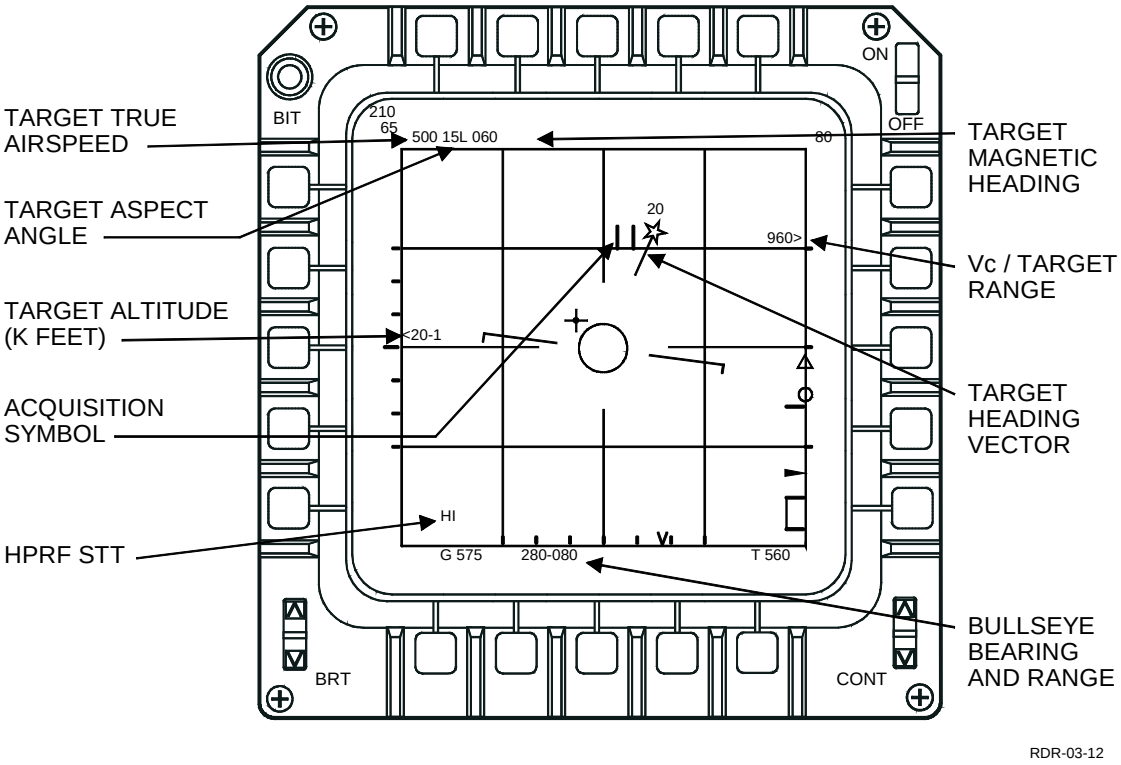

Figure D - 12. MRM, Initial Radar STT.

In STT with MRM selected on the weapon select switch, the acquisition symbol remains on the display to facilitate range bumping. Upon STT, the acquisition symbol initializes at target range and approximate target azimuth, but shifts 7.5° toward display center. Azimuth bumping is not available.

The intercept symbols in Figure D-13 track display include an allowable steering error (ASE) circle (solid for AIM-7, dashed for AIM-120), a steering dot, missile launch range symbols (Raero, Ropt, Rpi, Rmnvr, Rtr, Rmin) and time of flight (TOF) for the AIM-7 or time to active (TTA)/time to impact (TTI) for the AIM-120.

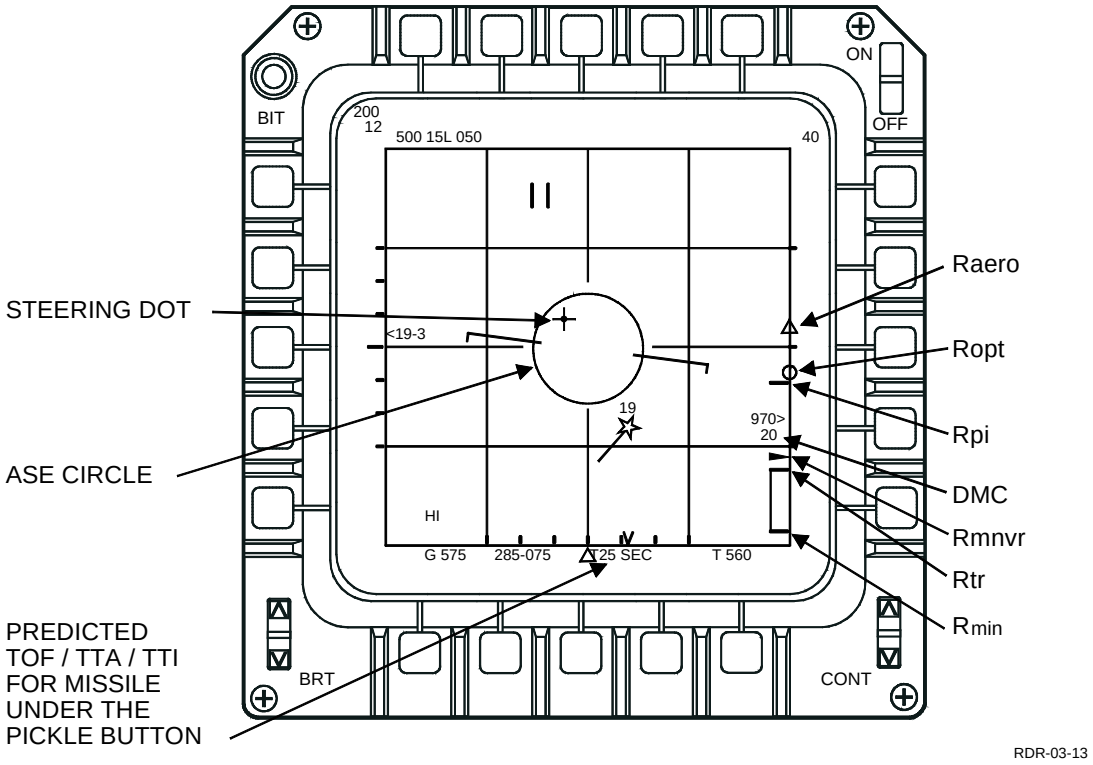

Figure D - 13. MRM Radar STT.

ASE Circle/Steering Dot

The ASE circle and steering dot relate lead angle error (LAE). The circle represents the maximum steering error that is normally acceptable for missile launch. The pilot should maneuver the aircraft to position the steering dot inside the circle.

MRM Range Symbols

The Raero, Ropt, Rpi, Rmnvr, Rtr and Rmin symbols display when radar track exists in MRM. Your aircraft velocity is assumed constant throughout the pickle to separation time for computation of all zones. Steering dot centered is assumed for computation of the displayed Raero and Ropt; actual (current) steering limited to the maximum size of the ASE circle is used for all other zone calculations. Refer to TO 1F-15E-34-1-1-1 for additional parameters used in determining missile ranges.

Raero (Maximum Aerodynamic Range)

Raero, indicated by a triangle, is the absolute maximum missile launch range and is calculated using optimal ownship steering, including lofting. This zone assumes that the target executes no maneuver (i.e., current velocity is assumed constant).

The first time a target intercept can be computed taking into account Raero constraints and current steering errors is known as Raero (current). The presence of the shoot cue indicates that Raero (current) has been reached.

Ropt (Maximum Range Probability of Intercept with Optimum Steering)

Ropt, indicated by a circle, is a special case of Rpi calculated assuming steering dot centered in the ASE circle (optimal steering) and is the same as Rpi in other respects. This zone assumes that the target executes no maneuver (i.e., current velocity is assumed constant with no acceleration).

For AIM-7s, Ropt cannot be greater than the calculated dynamic seeker range. DSR is not displayed.

Rpi (Maximum Range Probability of Intercept with Current Steering)

Rpi is the maximum launch range with current steering that assures a high likelihood of success. This zone assumes that the target executes no maneuver (i.e., current velocity is assumed constant with no acceleration). As the pilot optimizes the steering by centering the dot in the ASE circle, current steering closely approaches optimal steering, and Rpi approaches Ropt. With the dot centered, Rpi and Ropt are the same.

For AIM-7s, Rpi cannot be greater than the calculated dynamic seeker range. DSR is not displayed.

Rmnvr (Maximum Launch Range Against a Maneuvering Target)

Rmnvr (indicated by the sideways golf tee shaped symbol) represents the maximum launch range against a target executing a constant speed, level, 4-g turn towards the tail at launch, to a designated aspect angle as entered on the ARMT (Top Level PACS Menu, PB #16) display or via MC/DTM. If the current target aspect is less than the entered target aspect (i.e., closer to tail aspect), then Rmnvr equals Rpi. Entering 180° aspect (OFF displayed at PB #16) inhibits computation and display of Rmnvr since it is impossible to turn towards the tail and be at a head aspect when the turn is complete. Refer to TO 1F-15E-34-1-1-1.

Rtr (Range Turn and Run)

Rtr indicates the maximum launch range against a target executing an evasive turn and run maneuver at launch and is calculated assuming current ownship steering. A vertical line connects Rtr and Rmin. The target turn capability is based on F-15E specific power (Ps) curves under the following conditions.

- F100-PW-229 engines
- Clean aircraft
- 50% fuel remaining
- Maximum power
- Standard day

This zone assumes that the target executes a maximum g level maneuver with instantaneous g onset in the shortest direction to tail aspect; target speed is assumed constant until the target reaches tail aspect, and then increases per the capability in the conditions listed above.

Rmin (Minimum Launch Range)

Rmin is the minimum launch range that assures any likelihood of success. Target accelerations are assumed constant for the Rmin TOF. Your aircraft velocity is assumed constant throughout the pickle to separation time.

MRM Digital Maneuvering Cue (DMC)

The DMC appears just below the target Vc when the target range is less than or equal to Rpi and greater than or equal to Rtr. The cue indicates the maximum number of degrees the target can turn in the shortest direction towards the tail without defeating the priority missile for the current conditions. The target maneuver is a level 4-g turn initiated at pickle; target speed is constant. The radar displays a T when:

- the target aspect is tail, or
- a target turn to tail will not defeat the priority missile.

TOF/TTA/TTI

Predicted TOF/TTA displays between Raero (current) and Rmin with the steering dot inside the ASE circle. TOF/TTA updates for changes in target radar angle and range. For AIM-7 missiles, the letter "T" precedes this TOF to indicate time to impact. For AIM-120, time without any preceding letter indicates time to active after launch. If the letter "H" or "M" precedes this time, then the AIM-120 missile is already inside active range.

If target azimuth exceeds 45° right or left in STT, the radar goes into an expanded azimuth display and portrays azimuth out to 73°. A dashed line appears at 3/4 intensity to indicate the normal 60° azimuth limit (Figure D-14).

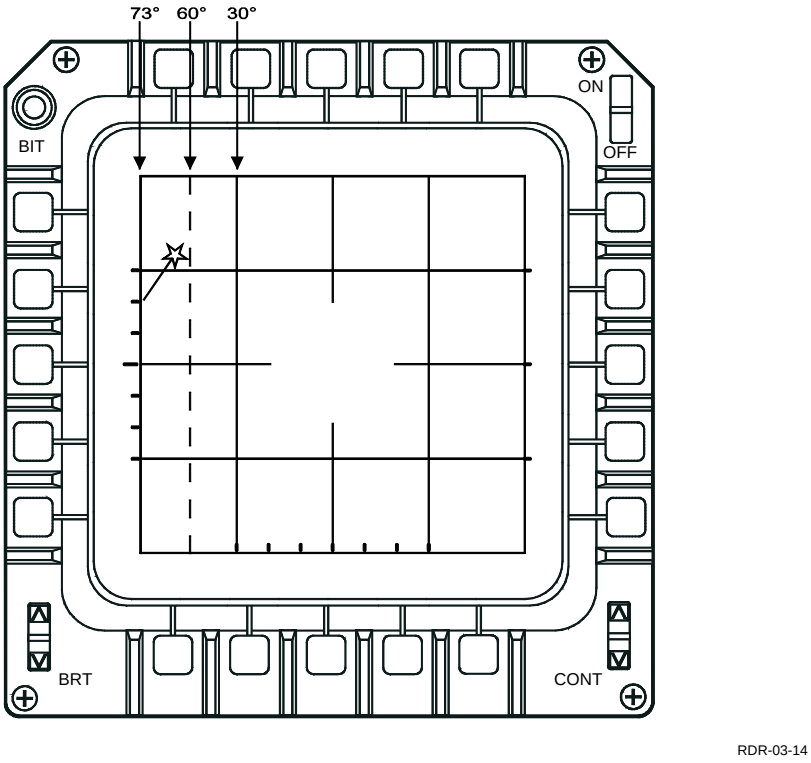

Figure D - 14.

The ASE circle and steering dot flash when azimuth reaches 65° to warn the pilot of approaching gimbal limit. The expanded azimuth logic is exited when target azimuth decreases to 40°.

With MRM selected and master arm switch in ARM, the triangular AIM-7 shoot cue (Figure D-15) displays when the following conditions exist:

- AIM-7 in priority and ready
- Radar in HPRF STT final track
- Steering dot inside ASE circle
- Target range between Raero (current) and Rmin
- Target range inside DSR (calculated but not displayed).

The shoot cue flashes between Rtr and Rmin.

With MRM selected and master arm switch in ARM, a six-pointed star AIM-120 shoot cue displays when the following conditions exist:

- AIM-120 in priority and ready
- Radar–STT, DTT, or DTWS
- Steering dot inside ASE circle
- Target range between Raero (current) and Rmin. (Shoot cue flashes between Rtr and Rmin.)

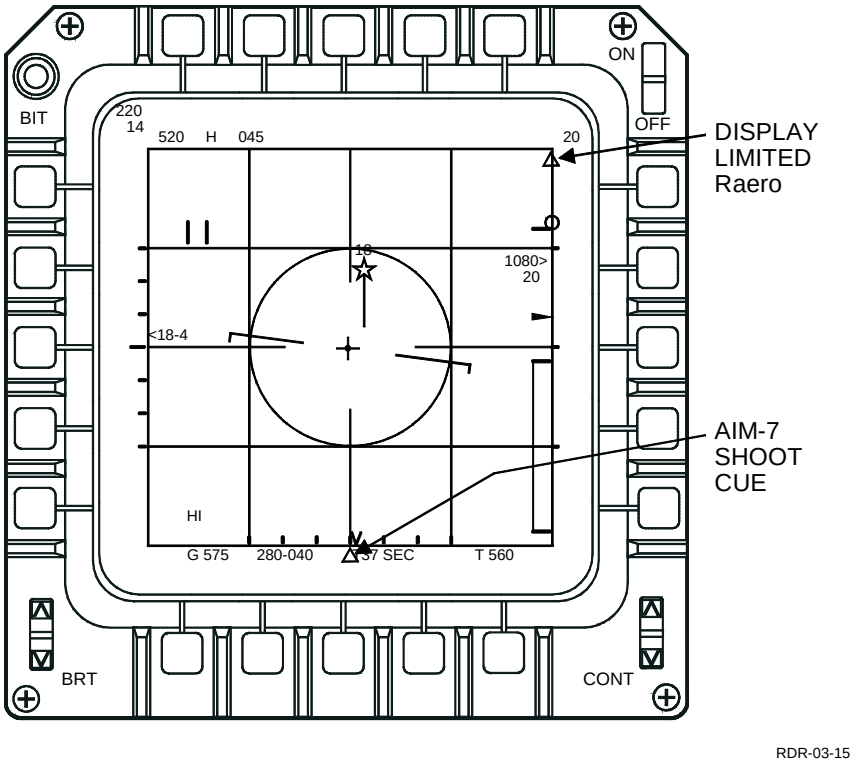

Figure D - 15. AIM-7 Shoot Cue.

After missile launch (Figure D-16), a missile in-flight cue appears along the target heading vector. The shortest/longest TOF/TTA/TTI for the missile(s) in flight begins countdown in the upper right corner of the display. The shortest TOF/TTA/TTI is furthest left. The times are updated (post launch) for target maneuvers. At predicted missile impact, TOF/TTI hits zero. Flashing dashes (--) replace TOF/TTI when TOF/TTI equals zero. The flashing dashes (--) display for 10 seconds.

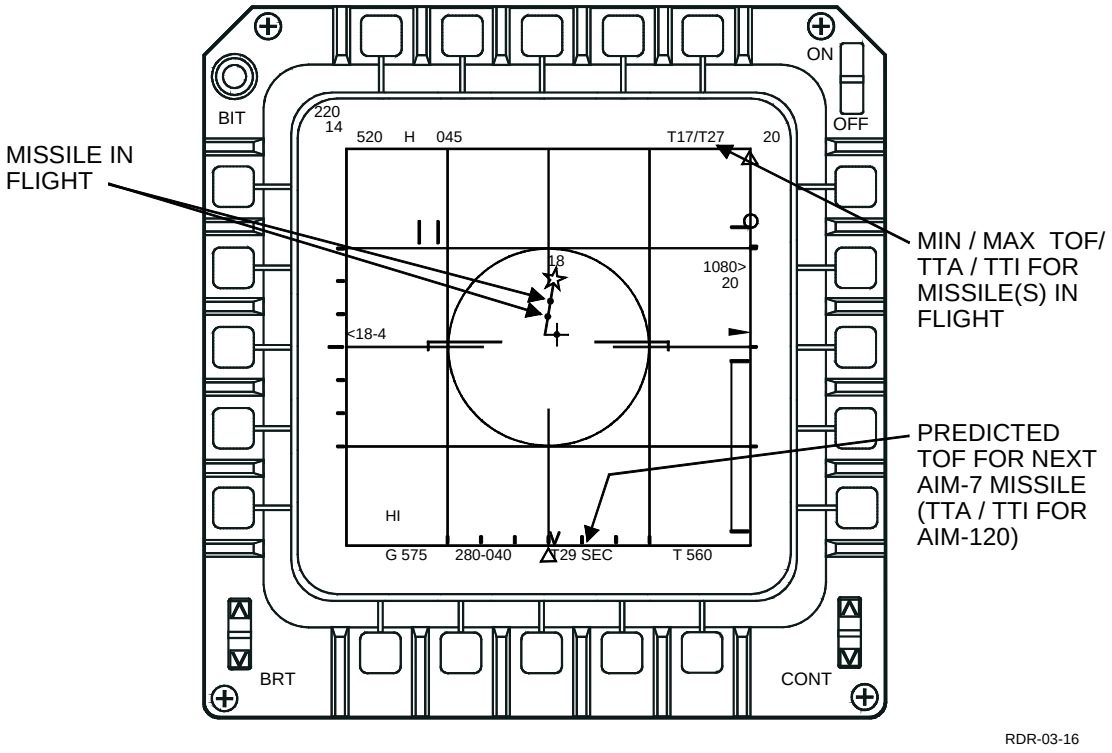

Figure D - 16. AIM-7 MRM Launch.

When target range decreases to inside Rmin, a flashing X symbol displays (Figure D-17). If an MRM has already been launched, the break X is displayed “steady” until missile time of flight to impact decreases to zero. The ASE circle and aim dot disappear at break X.

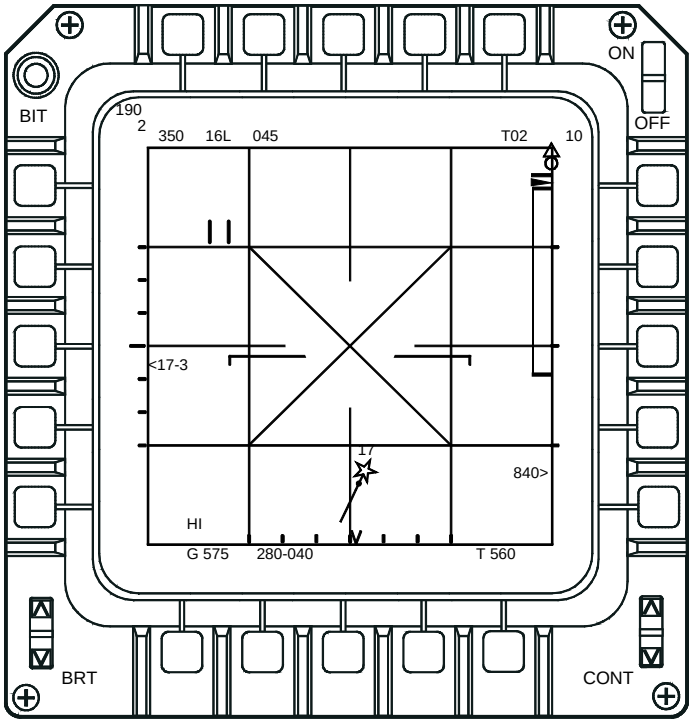

Figure D - 17. Steady Break X.

The AIM-9 track display (Figure D-18) is basically the same as the AIM-7 display. The SRM presentation has Rmax LC, Rmax HC, Rmin HC and Rmin LC range symbols. LC and HC means low confidence and high confidence respectively. Refer to TO 1F-15E-34-1-1 and TO 1F-15E-34-1-1-1 (classified) for the criteria defining LC and HC. The AIM-9 prelaunch TOF appears next to the shoot cue (preceded by an "S"). There is no in-flight time countdown like exists in MRM. The break X flashes immediately at Rmin LC, regardless of whether a missile is in flight. The acquisition symbols are not available in SRM.

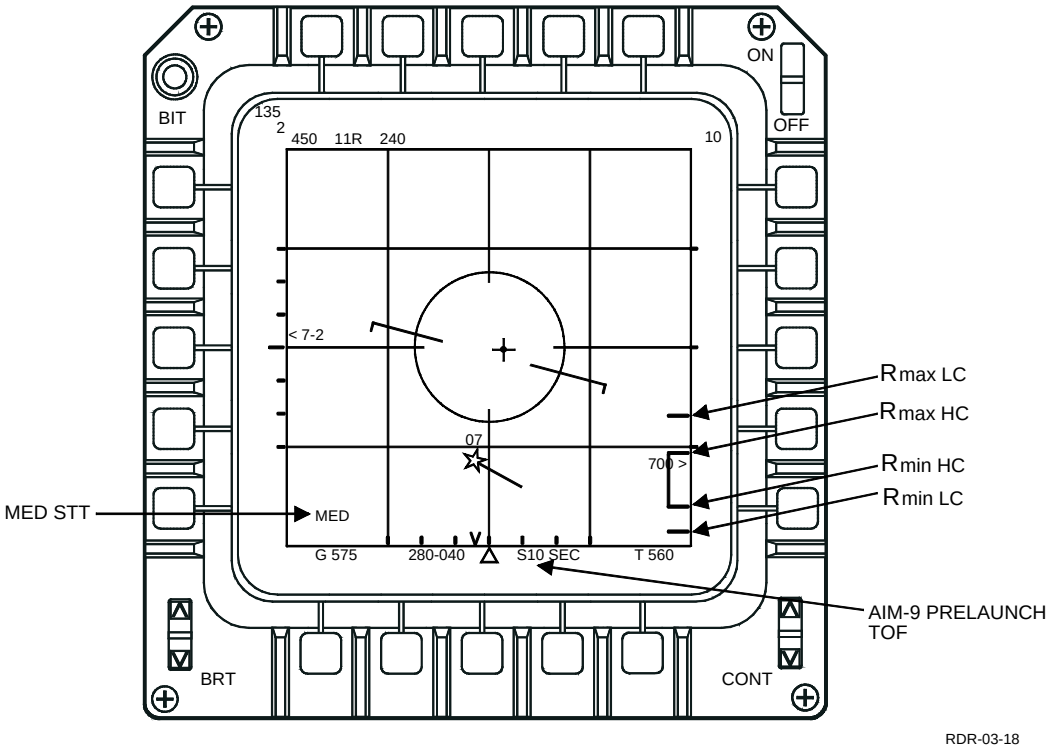

Figure D - 18. SRM STT.

The GUN STT track display (Figure D-19) is a backup steering presentation used when a visual on the target is lost. The circle represents the HUD FOV. If the HUD symbology is lost, the pilot flies to position the dot in the center of the circle to aid in establishing a tally on the target.

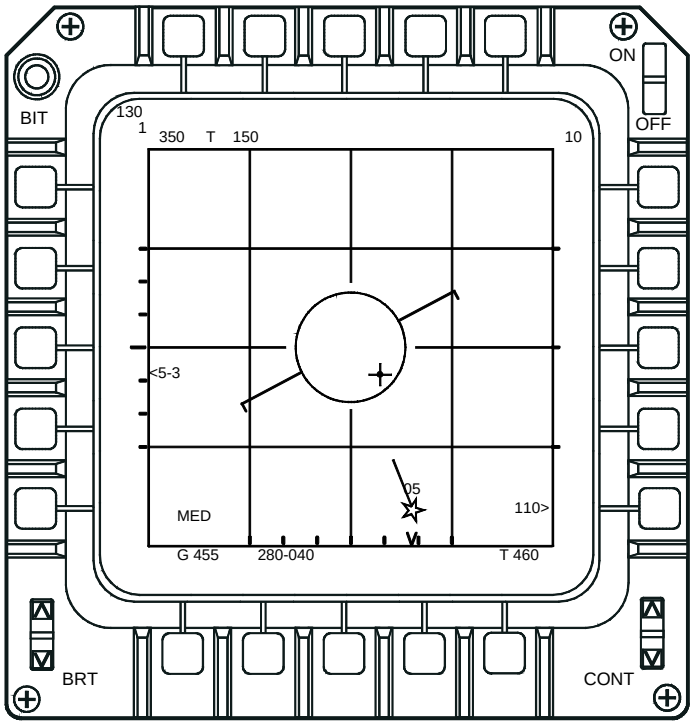

Figure D - 19. GUN STT.

GUN VS GUNS

GUN is a position on the weapon select switch. GUNS is a radar auto acquisition mode. If the radar is in STT or designated track-while-scan (DTWS), selecting GUN yields GUN STT (Figure D-19) immediately. With the radar in search, selecting GUN activates the GUNS radar auto acq mode. After auto acq lock on, GUN STT results.

Last Track Data

When the crew exits single target track to search, the last track data displays at the top left of the A/A radar display. The last track altitude information is shown where target TAS data was, and last track aspect angle is shown where target aspect angle data was displayed.

QUESTIONS

1. Manual lock on is typically employed in an intercept environment at _____ range.

2. SS, BST, LR BST and VTS are _____ modes.

   a. long range
   b. aircraft stabilized
   c. HPRF
   d. extreme pulse

3. The minimum radar target acquisition range of GUNS is _____ feet.

4. The heading vector symbol indicates target relative heading, and therefore does not move when the target maneuvers.

   a. True
   b. False

5. The ASE circle and steering dot, with MRM selected, relate _____.

6. The missile TOF indication in an SRM track presentation is preceded by an _____.

ANSWERS

1. medium to long
2. b
3. 3000
4. b
5. lead angle error
6. S

TRACK-WHILE-SCAN (TWS)

TWS is a mode that affords a near all-aspect, multi-target detection and track capability within a selected area. TWS can provide the "big picture" via rapid altitude sampling between targets, wide volume search and a plan view of target formations with heading vectors. Track data is made available with reduced effect on target RWR. In addition, TWS furnishes a situational picture for high confidence final sorts.

There are two different TWS rates and two different TWS modes available. The TWS rates are normal rate TWS (NTWS) and high data rate TWS (HDTWS). In NTWS, frame time varies from 2.2 to 2.6 seconds, and three scan patterns are available: 2 bar, 60° azimuth; 4 bar, 30° azimuth; and 6 bar, 15° azimuth. In HDTWS, two scan patterns are available: 3 bar/30° and 2 bar/30°. Frame time is 1.5 seconds in 3 bar HDTWS and 1 second in 2 bar HDTWS.

Designated TWS (DTWS) mode or nondesignated TWS (NDTWS) mode can use either of the two rates. Designated TWS ties the scan pattern around a primary designated target (PDT), which provides detailed information on that target, and also maintains track files on other targets. In NDTWS, the scan pattern is not tied to any target. (The search pattern can be positioned to the radar and elevation scan limits).

TWS selection is inhibited if GUN is selected on the weapon select switch, an AIM-7 launch is in progress, and/or an AIM-7 is in flight.

Switchology

Figure D-20 and D-21 depict STT/TWS switch logic. In Figure D-20 and D-21, "AUTO ACQ FWD/AFT" should be "MODE REJECT FWD/AFT" in RCP.

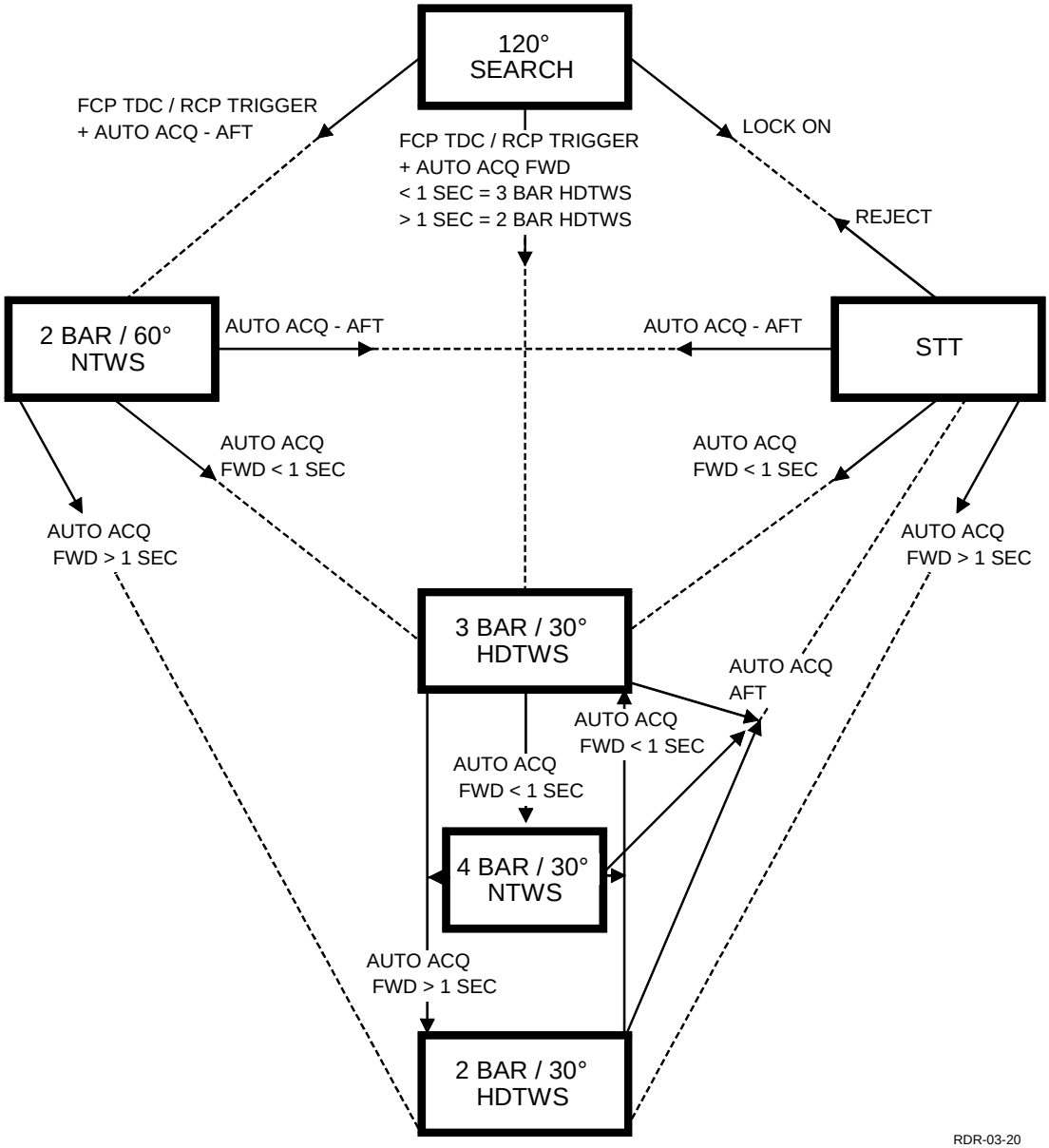

Figure D - 20. TWS Switchology (120° Search).

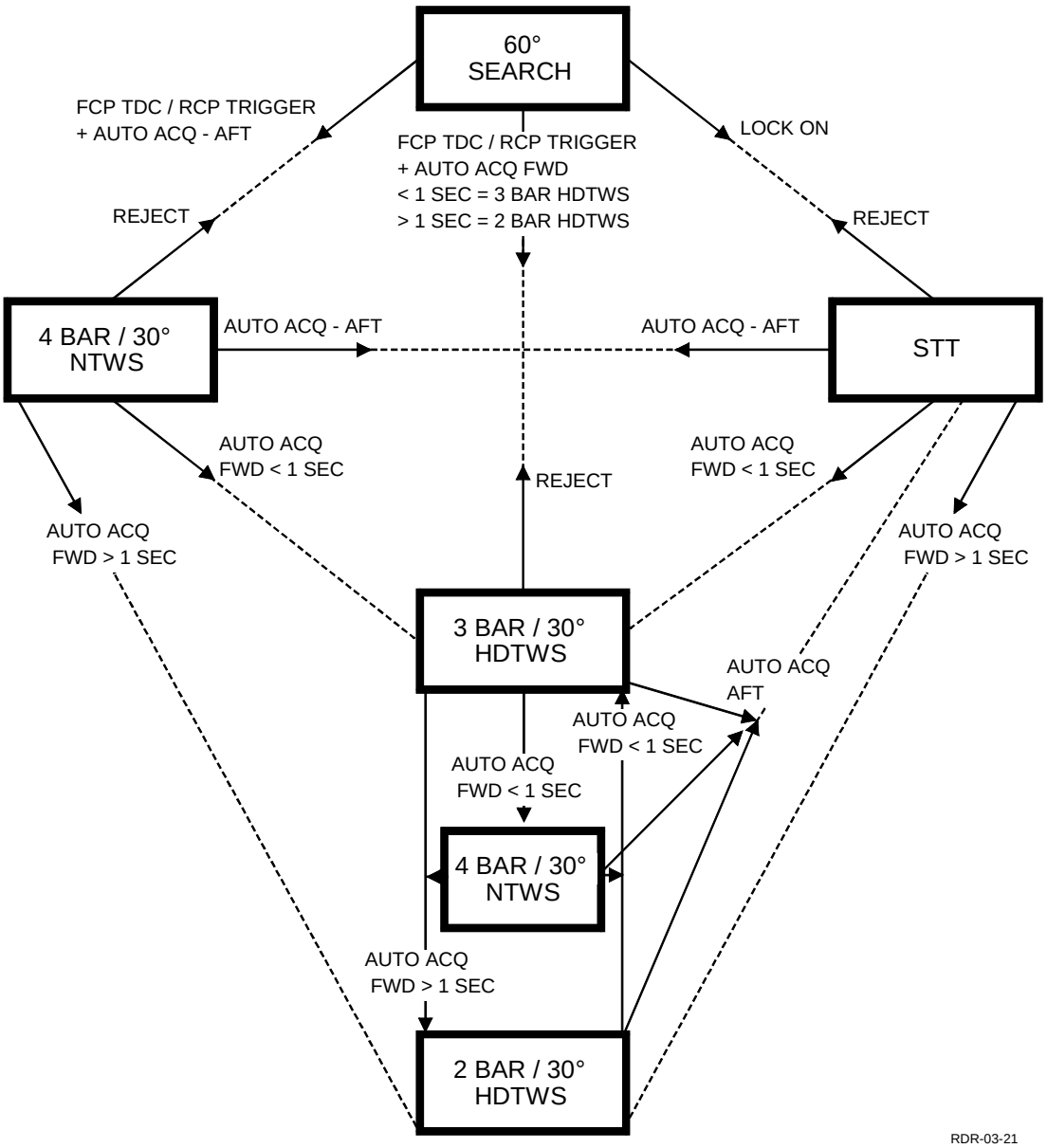

Figure D - 21. TWS Switchology (60° Search).

TWS Rates

From search, depress and release the FCP TDC or go full action on the RCP trigger, and thumb aft on the FCP auto acq/RCP mode reject switch to select NTWS or auto acq forward for greater than or equal to 1 second or less than 1 second selects different versions of HDTWS (see Figure D-20 and D-21). From STT, thumb aft on the auto acq/mode reject switch to enable NTWS. To enter HDTWS from STT, thumb forward greater than or equal to 1 second or less than 1 second on the auto acq/mode reject switch. To enter STT from either HDTWS or NTWS, thumb aft on the auto acq.

TWS Modes

Whenever the crew enters TWS from search (or if all targets are manually undesignated), the radar operates in NDTWS mode. If the crew initiates TWS from STT (or if the crew designates a track file in NDTWS by placing the acq symbol over the track file and pressing the FCP TDC/RCP trigger), the radar enters DTWS operation with a track file established from the designated target (STT) data. Thus it is possible to alternate between NDTWS and DTWS.

Positioning the weapon select switch to GUN (in DTWS) also causes the radar to enter STT. When the pilot selects GUN during NDTWS, the radar enters the auto acq GUNS mode. Note, depressing the auto acq switch (except in GUNS) eventually returns the radar to search.

Scan Patterns

Normal TWS (Designated or Nondesignated)

When the crew initiates NTWS, three AZ/EL scan parameters are selectable: 2 bar, 60°; 4 bar, 30°; and 6 bar, 15° TWS patterns respectively (Figure D-22). Az bumping is available to select between 2 bar, 60° and 4 bar, 30°. To select 6 bar, 15° position the acq symbol into the radar BIT window. The word "NARROW" will then appear in the BIT window. When "NARROW" is present, designate by pressing FCP TDC/RCP trigger, the scan becomes 6 bar, 15°. Az bumping changes from 6 bar, 15° to 4 bar, 30°. When the radar is in TWS, the radar BIT window reflects the number of bars of the elevation scan (2, 4 or 6) followed by the acronym "TWS," followed by the PRF in which the radar is operating (H for HPRF, M for MPRF, blank for interleaved PRF). As an example, if the radar is in 2 bar, 60° azimuth scan, medium PRF track-while-scan, the BIT window would reflect "2TWSM." Range scale switching also operates the same as in normal search (via the TDC).

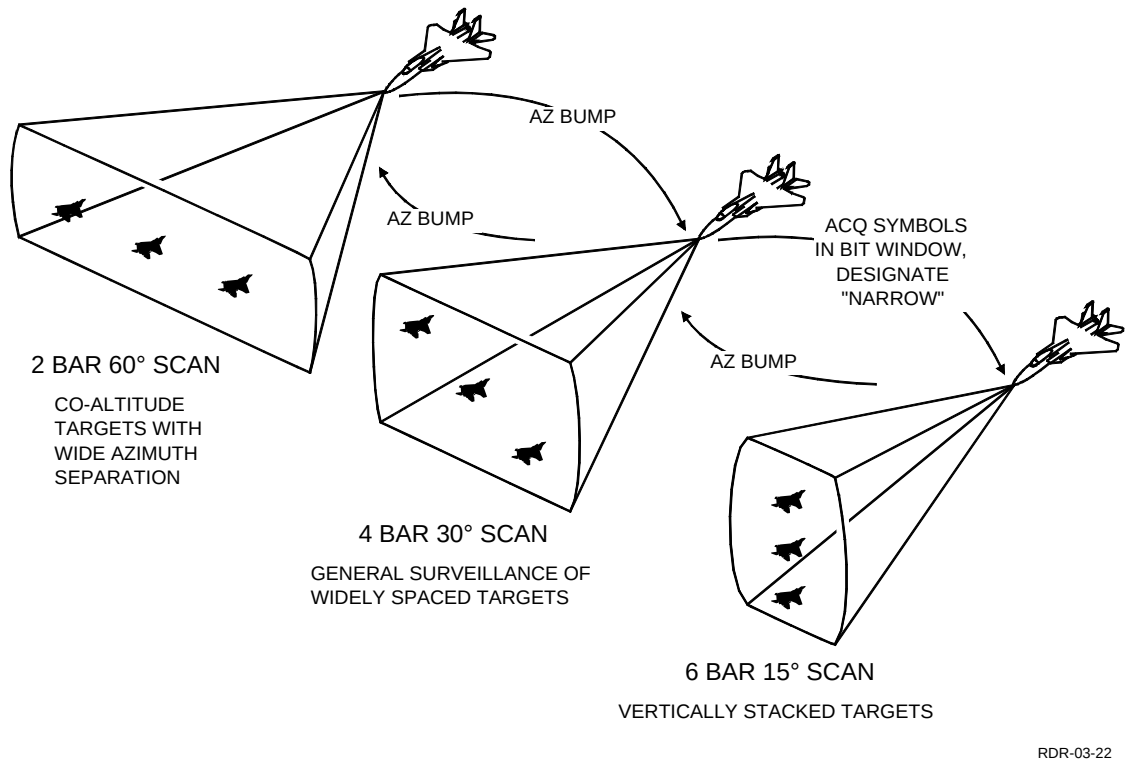

Figure D - 22. Scan Patterns.

The el wheel controls the elevation scan center in NDTWS. The acquisition symbol position determines the azimuth scan center. As the crew moves the scan pattern off the NDTWS targets, the track files go half intensity. If the files enter track memory (i.e., begin flashing), moving the search pattern back to cover the target AZ/EL position before or during flashing should update and retain the track files.

In DTWS, the radar automatically controls the elevation and azimuth scan center to accommodate the designated target(s) and other track file targets. Lower priority targets are deleted when all detected targets cannot be maintained within the elevation or azimuth coverage.

The crew can override DTWS azimuth scan logic by positioning the acq symbol left or right. Once the crew shifts the scan position in this manner, the radar automatically maintains only the primary designated target. The radar automatically recenters the az scan center with any subsequent target redesignation or azimuth bump.

DTWS elevation scan logic may be biased up or down in 4 and 6 bar TWS by normal antenna elevation HOTAS. The radar BIT window will indicate “UTWS” for up bias and “DTWS” for down bias. Designated targets will be retained in coverage.

High Data TWS

HDTWS (Figure D-23) is available in 2 bar/30° and 3 bar/30° scan patterns. The faster data gathering (frame time) provides an increased capability against maneuvering targets. AZ bumping in HDTWS will take you to 2 bar/60° NTWS. When in HDTWS, the radar BIT window reflects 2 HDT and 3 HDT to indicate 2 bar or 3 bar respectively.

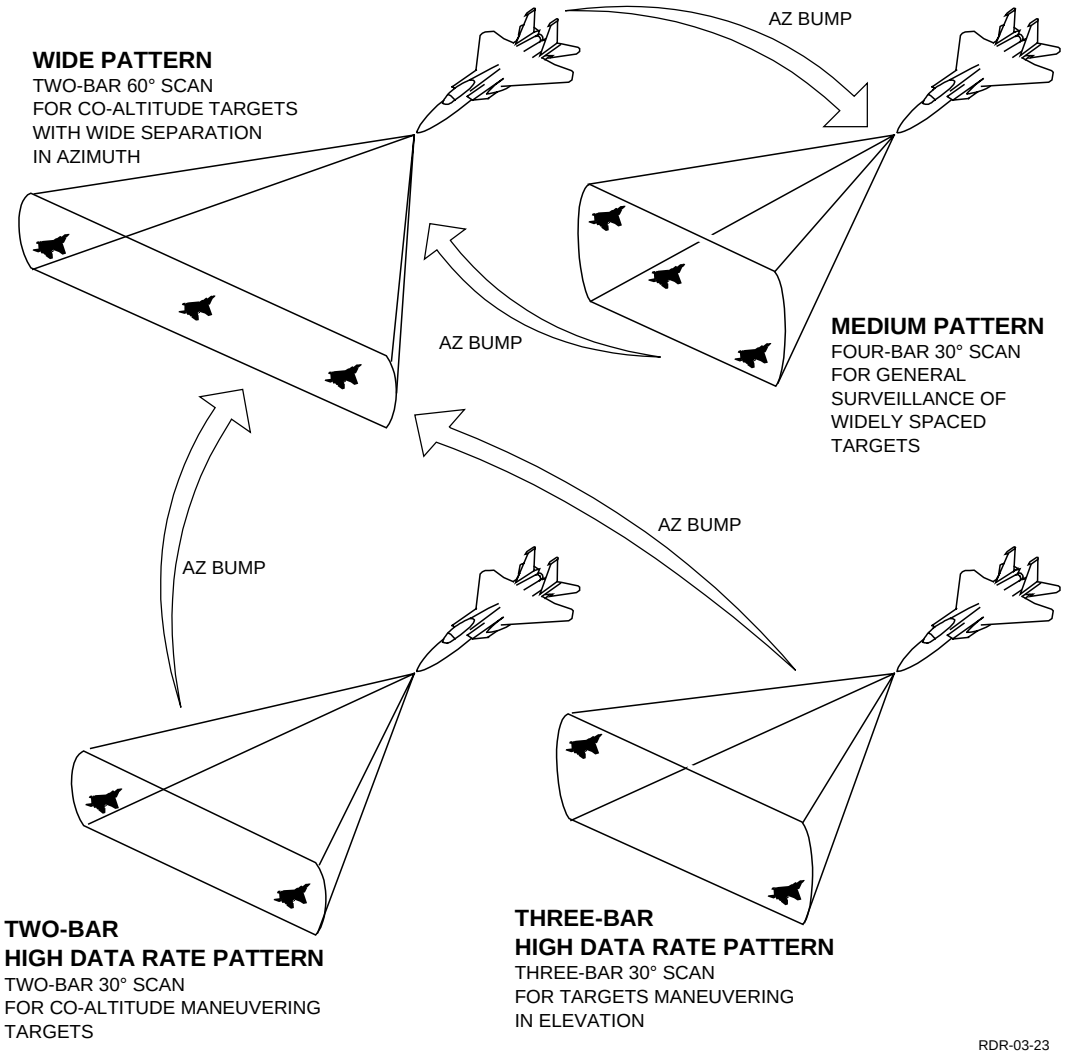

Figure D - 23. HDTWS.

Target Processing

The radar maintains track files (in terms of range, angle and rate) on up to 10 targets and supplies this data to the CC for correlation and update on an end of frame basis. The first hit produces an observation target (up to 20 of them) at the end of that frame. Observation targets are deleted if they do not receive a second hit within the next two frames (NTWS), or the next three frames (HDTWS). Targets that receive 4 hits become established track file targets, and are displayed with a relative heading vector.

All established track file targets abide by the following logic:

- Targets at ranges greater than 20 nm or less than 10 nm that have not been updated for 10 seconds are deleted (full intensity for 6 seconds, and then flash for 4 seconds).
- At ranges between 10 nm and 20 nm, a 15 second timer is used (11 seconds full intensity, 4 seconds flashing).

When track file range is beyond (not more than 10 nm beyond) the displayed range scale, these track files are maintained unless outside of radar coverage. If all the designated targets are deleted, the radar enters NDTWS.

Once a target has an established track file, it remains on the display and moves in a predicted direction based on the latest target hit. Thus, TWS can provide increased situational awareness through continuously displayed target information compared to the intermittent display of normal search.

Target Displays

NDTWS

The NDTWS display (Figure D-24) is similar to the standard A/A search display. The bar number readout indicates the number of bars in the selected scan pattern, rather than the current bar number as in normal search. When the crew selects HDTWS, HDT (i.e., HDTWS) follows the bar number. TWS track files begin as observation targets (half intensity symbol).

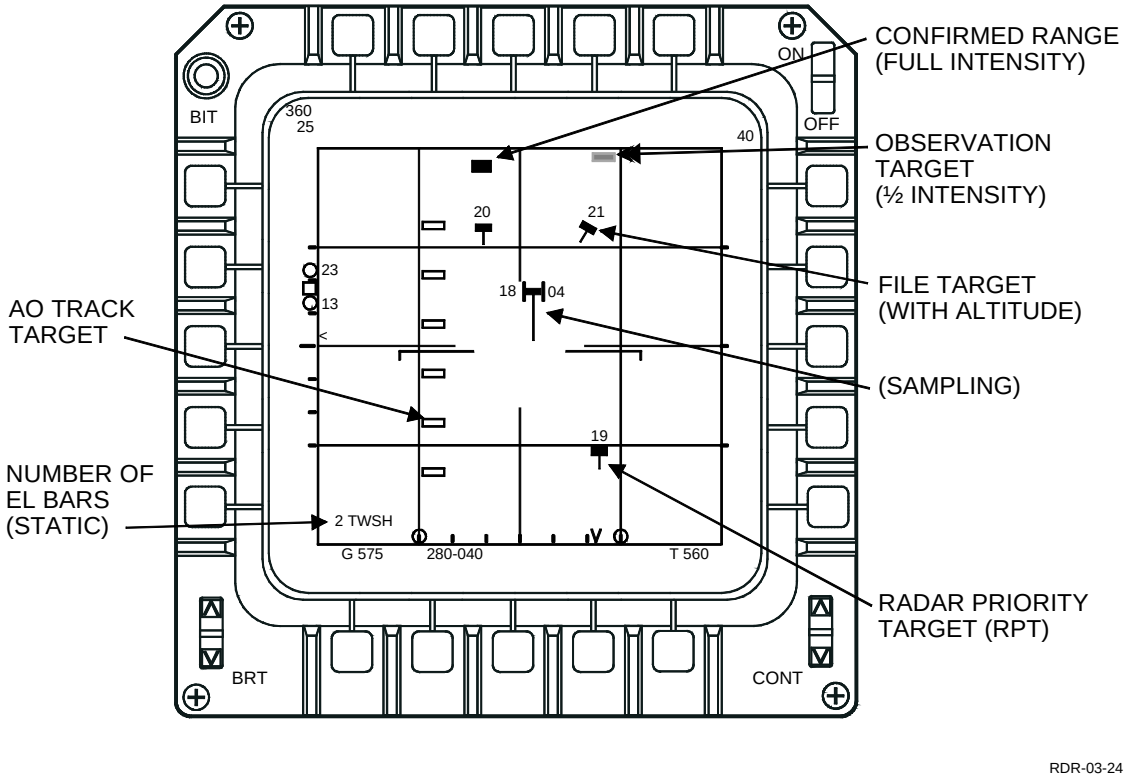

Figure D - 24. NDTWS.

Other target symbols are unique to the TWS display. Full intensity symbols with a relative heading vector indicate those targets for which the radar has sufficient correlation to maintain a track file and are inside the current scan coverage. Target altitude displays above track files with vector status. During NDTWS, the radar computer ranks the track file targets based on first merge criteria (aspect, range and velocity). The target determined to be the first merged target is called the radar priority target (RPT). A strobe of six open box symbols denotes angle only (AO)

track file targets. (Further discussion of AO and jamming targets will be provided in RDR-6.)

Placing the acquisition symbol over a short vector target (in NDTWS or DTWS) moves the altitude readout to the left of the acq symbols and target Mach number (if Mach ≤0.4 or ≥1.1) displays to the right. The vector stick will increase in length to a long vector.

DTWS

The crew may designate up to eight TWS targets (track or observation) via normal lock-on procedures. One designated target will be the primary designated target (PDT). The seven other TWS designated targets will be secondary designated targets (SDTs). After entry into DTWS (at least one target is designated initially), auto designation of all targets with vector status is possible by boxing "AUTO" at PB #10. Once designated, a target receives a long heading vector (Figure D-26). If you observe a high interest track file, and 8 targets have already been designated, one of those targets must be undesignated prior to designating the new file. To do this, slew the acquisition symbols over a lower priority designated target, and thumb aft on the FCP boat switch, or thumb left on the RCP castle switch (Figure D-25). (If the crew undesignates all targets in this manner, the radar enters NDTWS.)

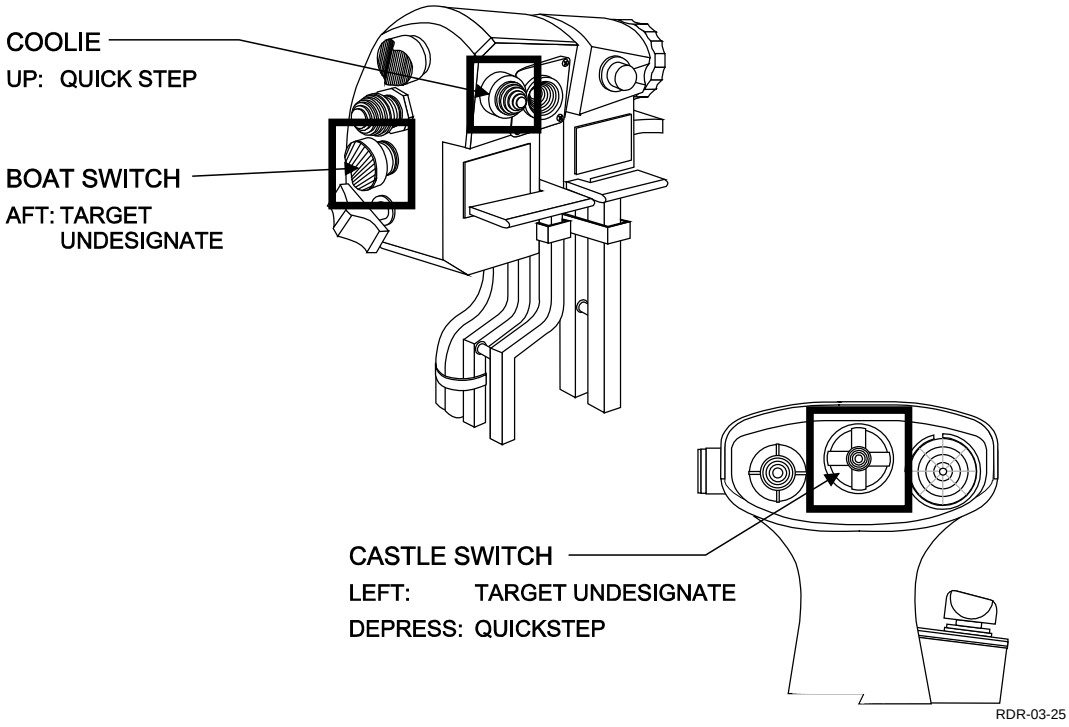

Figure D - 25. Undesignate/Quick Step.

The crew can move the PDT status to other SDTs via quick step. Momentary activation of quick step moves the PDT status to other SDTs in this order (you cannot quick step to nondesignated TWS targets):

- The SDT next farther out in range
- If the current PDT is farthest in range, then the left most AO SDT, and then left to right through the designated AO SDT
- If the current PDT is an AO track target farthest right in azimuth (i.e., lowest ranking), then the shortest range SDT becomes the PDT

Any SDT can be made the PDT by quick pick. Quick pick is accomplished by redesignating (less than one second) an SDT. That SDT then becomes the PDT.

When the crew removes the PDT status from a designated target by quick step or quick pick, the target reverts to an SDT.

The DTWS display (Figure D-26) is similar to the A/A track display. Altitude coverage of the scan pattern at acquisition symbol range is presented in addition to PDT parameters. The PDT (target toward which ordnance will be expended) is depicted as an open star with a heading vector. A jamming target PDT appears as four asterisks connected by a line. A symbol of six open boxes indicates an AO track file. (Four open boxes connected by a straight line indicate an AO secondary designated target.)

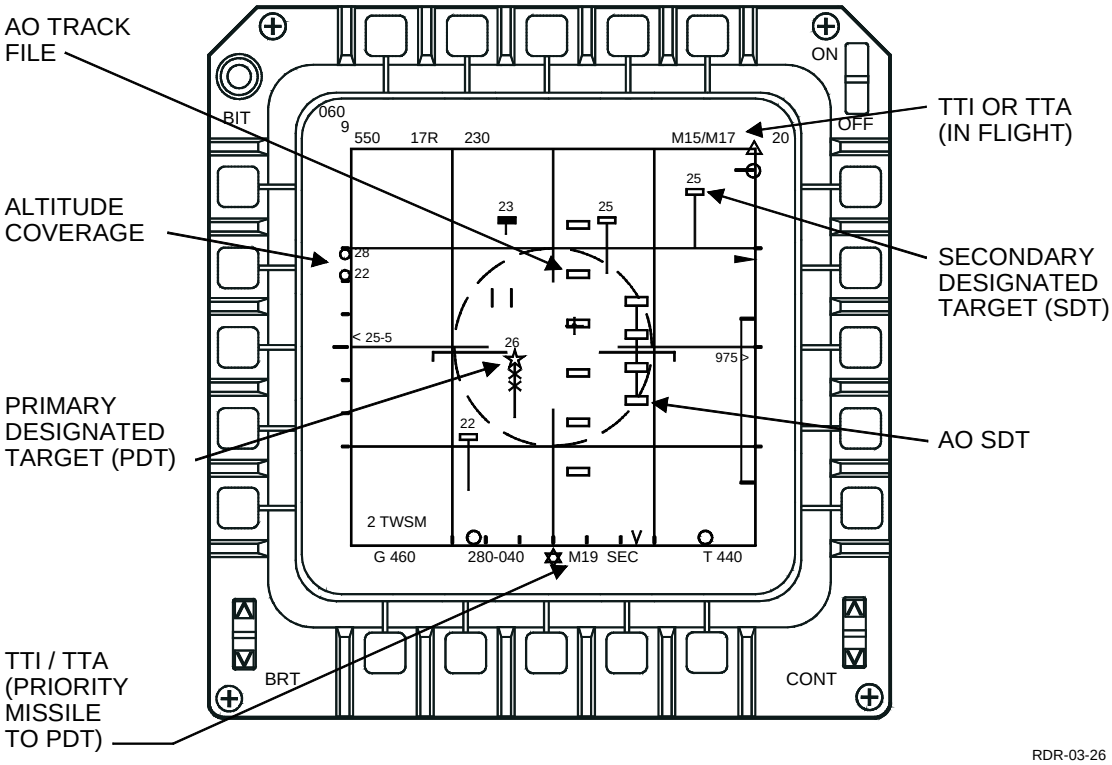

Figure D - 26. DTWS.

The dashed ASE circle, shoot cue (a six-pointed star), and missile launch parameters (Figure D-26) are specific to an AIM-120 presentation. Predicted TTI or TTA for the missile under the pickle button (priority missile) appears at the bottom center of the display for AIM-120. Minimum and maximum TTA/TTI for in-flight missiles displays to the left of the range scale at the top right of the display. With two or more AIM-120 missiles in flight, there will be two times: min TTA/TTI on the left and max TTA/TTI on the right.

TWS SORT

The TWS sort mode enables the crew to see "raw" MPRF target hits superimposed over a half intensity DTWS or NDTWS display. The legend at PB #9 on a TWS display is SORT. Select SORT (box) at PB #9 to enter the TWS SORT mode. For a complete discussion of the mode refer to TO 1F-15E-34-1-1.

Dual Target Track (DTT)

This TWS mode allows a two-target track capability of two widely spaced targets–a PDT and SDT. Independent scan patterns (2 mini frames) are used to track these two targets. These mini frames consist of two mini rasters of 4 bars with 4.5° azimuth, and 1.5° elevation bar spacing each. To enter DTT from DTWS, redesignate a secondary designated target for longer than 1 second. There are several options for exiting DTT. For more information, refer to TO 1F-15E-34-1-1.

QUESTIONS

1. When azimuth bumping from 2 bar, 60° azimuth TWS, the radar enters a _____ bar /_____° TWS pattern.

2. The radar priority target in NDTWS is radar selected and is _____.

3. If all designated targets are undesignated via the boat or castle switches, the radar enters search.

   a. True
   b. False

4. Attempting to quick step in TWS with only one target designated _____.

ANSWERS

1. 4, 30

2. the first merge target based on range, aspect, and airspeed.

3. b (enters nondesignated TWS)

4. has no effect

SEARCH SORT

Sort is a 30°, space-stabilized search scan (Figure D-27) that assists in rapid detection of closely spaced targets. The acquisition symbol and scan pattern stay pointed at the proper volume of space (within gimbal limits) to reduce crew workload during maneuvers. If the antenna reaches gimbal limits during this process, the 30° search continues at that limit. Azimuth bumping does not occur without moving the TDC. Elevation bars used are changed automatically according to radar range scale selected, and are not as selected at PB #2, "EL" control.

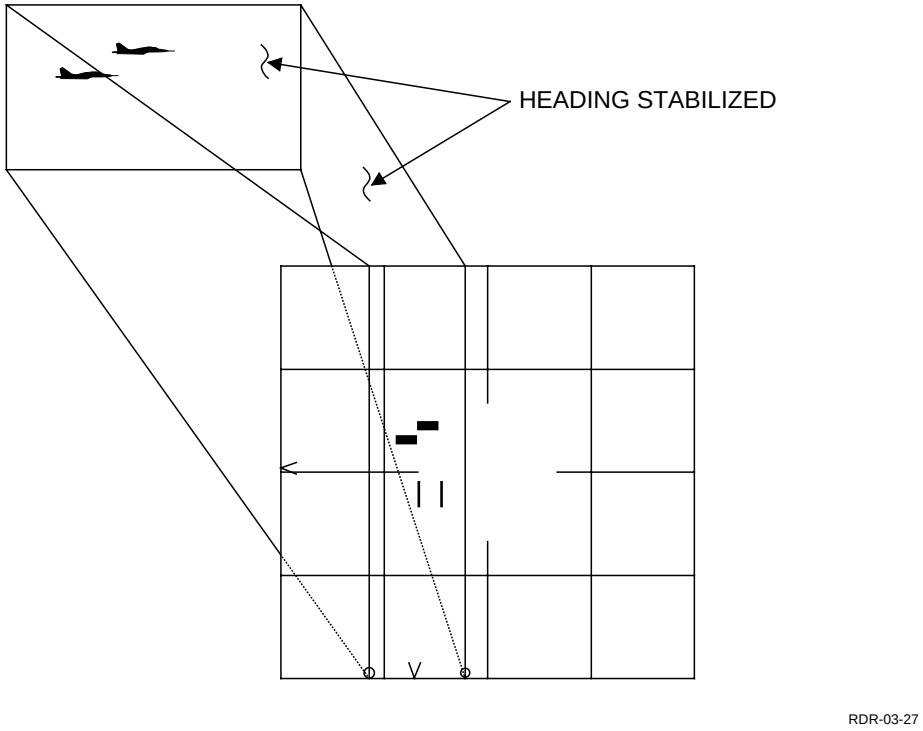

Figure D - 27. Sort.

Sort is selectable during search or STT. The scan centers at the acquisition symbol when entered from search. The crew selects sort from search by depressing the FCP TDC or going full action on the RCP trigger for more than one second. It is not possible to enter sort via azimuth bumping, or from auto acq or flood. When the crew selects MODE REJECT from auto acq lock, flood or STT, the radar initializes to the sort mode.

If the crew initiates sort while in STT, the radar breaks lock and the scan centers on the tracked target. If the crew initiates sort while in HOJ or HOJ track extrapolate, the radar enters sort scan centered on the jammer's az/el position. Sort scan locus is adjustable through normal controls for azimuth, elevation and range. The radar automatically controls bar spacing and the number of bars as a function of the radar range scale.

This sort mode is not the same as the TWS SORT mode presented earlier in this workbook.

FLOOD

Manual Selection–MPRF

If lock on by the preferred methods cannot be obtained, MPRF flood mode can be manually selected via PB #13 on the MPD/MPCD. The FLOOD command from PB #13 is ignored in STT, TWS, or BIT. The main antenna drives to a 60° look-down angle (to clear the path for the flood antenna) and the flood antenna output is energized (MPRF). The FLOOD cue appears below PB #19. This mode can provide backup air-to-air gun ranging (out to 2 nm) for the nearest target within flood range and flood antenna beamwidth. MPRF flood ranging is used with the LCOS track funnel gunsight display in the HUD.

Manual Selection–HPRF

If the radar is in STT or DTWS, the pilot can manually select HPRF flood illumination at AIM-7 missile launch by holding the FCP coolie switch down prior to and while pressing the pickle button.

The crew can also manually select HPRF flood illumination after an AIM-7 launch in STT by pressing aft on the auto acq switch for greater than 1 second.

Automatic Selection–HPRF

Flood horn HPRF radiation is automatically provided at certain times during AIM-7 operations. HPRF flood is automatically provided at AIM-7 launch if the radar is in search. Auto flood also occurs during HPRF track extrapolate (memory) operations if the target is inside of flood antenna range and FOV, or if HPRF track is not achieved within 1 second of launch initiation from STT, or 3 seconds from DTWS.

The radar attempts a confirmed HPRF track upgrade within ½ second of launch initiation from MPRF final track or HPRF probationary track. If unsuccessful, HPRF flood illumination activates. The launch-to-eject cycle is not delayed.

The launch cycle delays for up to 3 seconds when the MRM fire signal occurs during DTWS operation. If the radar does not achieve HPRF STT within this 3 second period, the radar initiates flood illumination for missile launch. The radar does not delay HPRF FLOOD at launch when targets are within the FOV at less than 5 nm in the front and 3 nm in the stern.

HPRF flood illumination is effective to approximately 8 nm, depending on target size. As in manual HPRF flood operations, the HUD is the primary attack reference. The pilot steers to maintain the target within the 12° MRM reference circle during the AIM-7 fly out.

Any activation of the auto acq switch suspends automatic flood ops and commands the selected mode. (GUNS scan does not interrupt flood.)

Refer to TO 1F-15E-34-1-1-1 for additional information.

Velocity Search Boresight (VS BST) Mode

The VS BST mode provides HPRF AIM-7 illumination similar to the FLOOD mode except that VS BST uses the main antenna. The radar enters VS BST when the auto acq switch is pressed forward for greater than one second while the radar is supporting an AIM-7 shot. VS BST appears in the radar BIT window, at the top of the A/A radar display and VS replaces the scope range value. The radar does not display target detections or the acq symbol. A 2.5° circle is shown on the HUD.

VS BST is exited as follows:

- Mode reject–return-to-search to selected search mode
- Select GUN–GUNS mode selected
- Select supersearch–supersearch
- Auto acq aft greater than 1 second–HPRF FLOOD

VISUAL IDENTIFICATION (VI)

The crew selects the VI mode by pressing PB #5 on the MPD/MPCD (Figure D-28). The VI option is only available at PB #5 when the radar is in STT (VI is not available with GUN selected). With VI selected, the CC provides steering information to guide the aircraft directly behind the target. Steering computations are a function of F-15E velocity, target aspect and range.

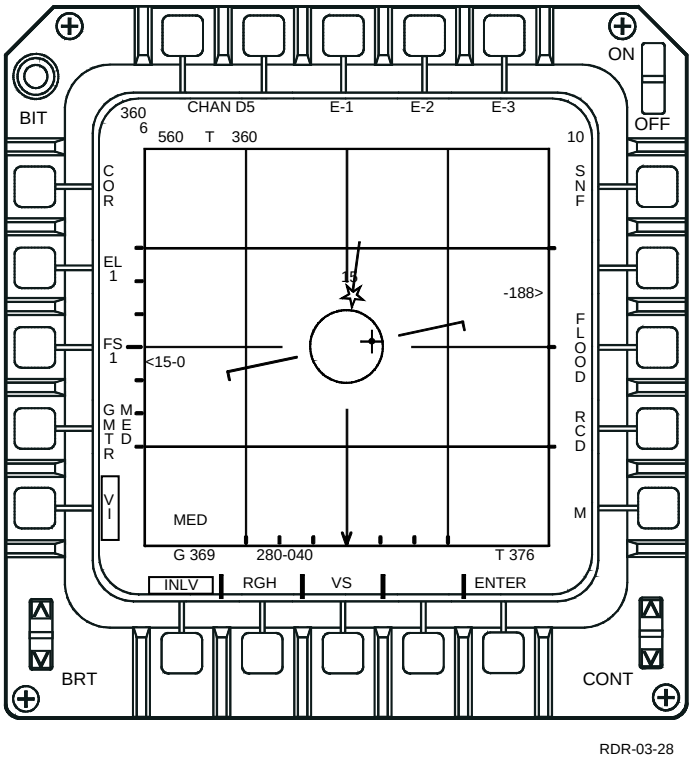

Figure D - 28. VI.

For nose through beam aspects, steering the dot into the ASE circle provides lag angles between 15° and 45° to avoid excessive lateral offset or high-G maneuvering during the conversion turn. For target aspect angles less than 90°, the steering is pure pursuit to the target.

The VI radar display does not contain MRM/SRM range symbols. The ASE circle has a fixed diameter until 1.6 nm range (10,000 feet), where the circle increases in size, representing a 500-foot circular radius about the target. Keeping the steering dot on the ASE circle perimeter will assure 500-foot lateral separation. If the range is less than 1 nm, and Vc is greater than 50 knots, the Vc will flash (HUD and A/A radar). A flashing break X appears at 1500 feet or 30 seconds to collision, whichever is greater. The ASE circle and steering dot remain on the display during break X.

WARNING

The gun and A/A missile firing circuits are still operational in the VI mode.

QUESTIONS

1. The search sort scan pattern is adjustable via the _____.

2. Manual flood selection by pushing PB #13 provides MPRF____ only.

   a. angle
   b. flood ranging for air-to-air gunnery out to 2 nm
   c. velocity
   d. HPRF

3. In VI mode, the GUN, SRM and MRM weapon fire circuits are nonfunctional.

   a. True
   b. False

ANSWERS

1. TDC and el control

2. b

3. b

GLOSSARY

A	All
A/A	Air-to-air
AA	Aspect angle
AO	Angle only
ASE	Allowable steering error
Az	Azimuth
BIT	Built-in test
BST	Boresight
CC	Central computer
DMC	Digital maneuvering cue
DSR	Dynamic seeker range
DTT	Dual target track
DTWS	Designated track-while-scan
EL	Elevation
EW	Electronic warfare
FOV	Field of view
H	High
HDT	High data track-while-scan
HDTWS	High data track-while-scan
HOJ	Home on jam
HOTAS	Hands on throttle and stick (and controller)

HPRF High pulse repetition frequency

INS Inertial navigation system

LAE Lead angle error

LOS Line of sight

LR BST Long range boresight

M Medium

MPRF Medium pulse repetition frequency

MRM Medium range missile

N Normal

NDTWS Nondesignated track-while-scan

NTWS Normal track-while-scan

PDT Primary designated target

PRF Pulse repetition frequency

RBL Radar boresight line

RTS Return to search

S SRM Time

SS Supersearch

STT Single target track

T Time (AIM-7)

TAS True airspeed

TD Target designator

TDC Target designator control

TEWS Tactical electronic warfare system

TOF Time of flight

TTA Time to active

TTI Time to impact

TWS Track-while-scan

Vc Velocity of closure

VI Visual identification

VS Velocity search

VS BST Velocity search boresight

VTS Vertical scan